

Republic of Iraq
Ministry of Higher Education
And Scientific Research
University of Baghdad
College of Dentistry



Cement And Base Materials

Graduation Research Submitted to Collage of Dentistry/
Department of Conservative / University of Baghdad in partial
fulfillment of the requirement of Bachelor in operative Dentistry

By

Hiba Ahmed Sahi

Supervised by

Dr. Mirvet M. Al-Bakri

B.D.S., M.Sc.

2023 A.D.

1444 A.H

Declaration

I certify that this project entitled "Cement and base materials" was prepared by the fifth-year student Hiba Ahmed Sahi under my supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor Degree in operative Dentistry.

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

{وَأَنْ لَيْسَ لِلإِنْسَانِ إِلَّا مَا سَعَى * وَأَنَّ سَعْيَهُ سَوْفَ يُرَى *
ثُمَّ يُجْزَاهُ الْجَزَاءَ الْأَوْفَى {

صَدَقَ اللَّهُ الْعَلِيِّ الْعَظِيمِ

سورة النجم (39-41)

DEDICATION

To my great parents, I would not have reached without your prayers and support for me, incorporeal and financially, I will Never forget your Standing beside me as long as I live, in fact (you are the ones who deserve this graduation certificate).

To my grandfather, who I am attributed to him, and to the pure lineage of his sons (Peace Be Upon All Of Them); Without your spiritual support for me and your prayers, it would be impossible for me to arrive.

To my brother, sisters, friends, who shared their words of advice and encouragement to finish this research.

To my supervisor for her guidance, help, encouragement and support.

Acknowledgment

First of all, thanks and praise to Allah, the Almighty, for inspiring and giving me strength and patience to complete this work, praying and peace be upon His Prophet Mohammed and his Household. I would like to express gratitude to **Prof. Dr. Raghad A. Al- Hashimi**, the Dean of the College of Dentistry, University of Baghdad and to **Asst. Prof. Dr. Anas F. Mahdee**, the chairman of the department of Restorative and Esthetic Dentistry at the University of Baghdad for their continuous support for the undergraduate students. Gratitude and heartfelt thanks to my supervisor **Dr. Mirvet M. Al Bakri** for her kind advice, continuous motivation and encouragement.

List of Contents

No.	Subject	Page No.
	Introduction	6
I.	Definitions	7
II.	Classification and terminology of intermediate filling materials.	8
II.A	Cavity Varnish	8
II.B	Cavity sealer	9
II.B.1	Resin based cement	9
II.B.2	Self-adhesive Cements	10
II.C	Cavity liners	11
II.D	Cavity Bases	11
II.D.1	Zinc phosphate cement	11
II.D.2	Poly carboxylate cement	12
II.D.3	Calcium hydroxide cement	14
II.D.4	Zinc oxide eugenol cement	15
II.D.5	Glass Ionomer Cements (GIC)	16
II.D.6	Resin Modified Glass Ionomer Cement	20
II.D.7	Glass Carbomer	21
II.E	Newer advances of Glass Ionomer Cement	23

Introduction

Introduction

One of the aims of operative dentistry is to preserve the pulp vitality in compromised teeth: one method used for this reason is the use of liners and bases. This involves the placement of protective materials on the unexposed pulp to maintain its health and to stimulate defensive repair by tertiary dentine deposition. The use of liners and bases under restorations has been common practice for many years and continues to be promoted in operative dentistry textbooks as an essential part of restorative procedures. **(Heymann H et al, 2013)** .

The concepts related to pulp protection have been constantly revisited as the knowledge and understanding of the tooth and dental materials evolve. Traditionally, liners have been used to protect the pulp from the potential toxic effects of restorative materials. Currently, liners are used for their therapeutic effect and/or to seal the dentinal tubules against the ingress of microorganisms or their by-products at the restoration—tooth interface. **(Ritter AV& Swift Jr EJ, 2003)** .

A variety of dental materials have been introduced as liners to provide pulp tissue protection from irritants related to the restorative procedure. The traditional lining materials include calcium hydroxide, glass ionomer, and resin-modified glass ionomers (RMGIs). Calcium hydroxide has been considered as gold standard for a long time and enjoys the greatest popularity among general dentists.

In clinical practice, calcium hydroxide has been reported as liner of choice in patients with deep cavities. **(Aljanakh M et al, 2016)**.

I.Definitions:

Liners

Liners are materials that are placed as thin coatings (usually 0.5 mm) on the surface of cavity preparation. Although they provide a barrier to chemical irritants, they are not used for thermal insulation or to add bulk to a cavity preparation. Furthermore, these materials do not have sufficient hardness or strength to be used alone in a deep cavity. (**Anusavice, 2003**).

Benefits of use of liners:

1. provide adequate sealing and protection to the dental pulp due, in part, to the chemical adhesion to dental substrates.
2. Some of the liners can release fluoride.
3. prevent bacterial growth under restorations.

(**Naji Ziad Arandi, 2017**).

Bases: Layer of insulating, sometimes medicated, cement placed in the deep portion of the cavity preparation to protect the pulp from thermal and chemical injury. (**Anusavice, 2003**).

Benefits of use of bases:

1. A barrier against chemical irritation.
2. Provide thermal insulation.
3. The clinician can shape and contour base materials after placement into the cavity preparation.
4. Mechanical protection by resist forces applied during condensation of the restorative materials. (**Randy weiner, 2003**).

Dental cements

Are materials of multiple uses including restorations, luting and therapeutic .They are generally materials of comparatively low strength, but have extensive use in dentistry (**JOHN J MANAPPALLIL , 2016**)

Classification of Cements

Cements can be classified as follows:

1. **Temporary (provisional) cements:** including calcium hydro-oxide and zinc oxide-eugenol cement, are placed beneath temporary restorations in the interval between preparation and delivery of the final restorations that can vary from several weeks to several months, depending on the clinical situation presents at the time of preparation. Some of the clinical requirements of temporary cements include ease of handling, optimum setting time, good marginal seal to prevent microleakage and recurrent decay. **(Yu Het al, 2014).**

2. **Permanent cements:** In the past (and still), the term “permanent cement” has been frequently employed when describing dental cements for the final restorations. As a matter of fact, a more proper description of cement should be “definitive cement” when describing a cementation cannot be removed at a later time including zinc phosphate, zinc poly-carboxylate, conventional glass-ionomer cement, resin-modified glass-ionomer cement and resin cement **(Cornelis H Pameijer, 2016).**

Required cement properties: At present, the search for perfect cement, which will maintain and protect the tooth tissues, have high resistance to tension and pressure, prevent tooth decay on the cement contact surface still persists. The matter should be biologically compatible with pulp, with antimicrobial activity, ensure edge impermeability and provide a layer of minimal thickness; it should be easy to use, poorly soluble, have optimal working and curing duration. Besides, this type of cement should manifest high resistance to breakage, optimal wettability and sufficient viscosity. Removal of excess cement should be as effortless as possible. **(Pegoraro et al, 2007).**

II. Classification and terminology of intermediate filling materials.

II.A Cavity Varnish: A varnish consists of one or more resins (from natural gum, synthetic resins or rosin) in an organic solvent (acetone, chloroform or ether). Varnishes are applied in a thin layer to the cavity preparation and on evaporation of the solvent, the remaining solute is the liner which seals the tubules. Therefore, varnishes can be considered a liner.

They also fit the definition of a liner in that they seal the dentine, but are contraindicated when a resin composite is going to be placed. (**Anusavice K, 2003**.)

A cavity varnish provides a protective barrier against irritants (from restorative materials) and from the oral fluids penetrating into the dentine. Varnishes also protect the tooth from the newly placed amalgam. A fresh amalgam shrinks on setting, allowing microleakage to occur, and a varnish will seal the cavity-amalgam interface until the amalgam starts to corrode. Varnish also keeps the corrosive by-products from leaching into the enamel and staining the tooth. (**Craig RG, Powers JM, 2002**).

Even when varnishes are applied in multiple layers, it is possible that microscopic openings may form in the varnish and this might allow bacteria to penetrate into the dentine. (**Royse et al, 1996**) have concluded that varnishes are not as effective as other materials at reducing microleakage.

II.B Cavity Sealer:

Materials provide sealing as well as bonding at the interface between cavity preparation walls and restoration such adhesive bonding systems, resin luting cements and glass ionomer luting cement. The film thickness is 20-50 μm .(**Randy weiner, 2003**).

II.B.1 Resin based cement

As an alternative to acid-base reaction cements, resin-based cement was introduced in the mid-1980s, these materials have a setting reaction based on polymerization. Resin based cement are polymers to which a filler has been added to reduce the coefficient of thermal expansion (CoTE) and water sorption thereby increasing the strength of polymers, fluoride also added. One of the first resin cement was marketed by Dentsply/Caulk under the name Biomer, around 1987. These are widely used cement for nonmetallic restorations, resin-bonded fixed partial dentures, ceramic crowns, and porcelain veneers, as well as ceramic and resin composite inlays and analysis two clinical studies by (**Pameijer, 2016**) (unpublished data), the cement performed well over a one-year period of evaluation. However, over time polymer degradation occurred due to hydrolysis, while a lack of bonding to enamel and dentin made the cement unsuitable as a stand-alone luting agent, leading to leakage and failure of the restoration. Additionally, incomplete polymerization can lead to irritation of the pulp

by unreacted monomers. In combination with a dentin bonding agent, however, many resin cements have superior properties and are frequently used for the cementation (bonding) of porcelain laminate veneers. **(Cornelis H Pameijer, 2016).**

These are classified into three types based on the method of polymerization as chemical-cured, light-cured and dual-cured. The acidic nature of the primer dissolves the smear layer and the surface hydroxyapatite, which allows for the adhesive component of the primer to infiltrate the exposed dentinal collagen. This results in the formation of the so-called 'hybrid layer' and a zone of occluded dentinal tubules, and the solvent (either acetone, alcohol or water) then evaporates. The adhesive (bond) is then placed, which is a low viscosity, hydrophilic material that promotes the bond of the filled resin to the tooth. **(Anusavice K, 2003).** Complete penetration of the primer monomers into the collagen is essential to create strong adhesion as well as an optimum seal. The occluded tubules reduce the amount of microleakage.

II.B.2 Self-adhesive Cements

They are the newest category of resin cements and these are aesthetically appropriate for cementing all-ceramic crowns, porcelain inlays and onlays. Self-adhesive cements contain acrylic or diacrylate monomers and specific adhesive monomers that are sufficiently acidic to produce their self-adhesive properties. These cements have evolved because of the desire of clinicians/operators to simplify the luting procedures for resin cements and, more importantly, to shorten their window of contamination. SACs are dual-cured resin cements, which can bond to an untreated tooth surface that is neither micro-abraded nor pre-treated with an etchant, primer or bonding agent. They have similar bond strength to self-etching systems, with cementation being accomplished in a single step, thus overcoming the limitations of the conventional total-etch resin cements. **(Burgess JO et al, 2010).** Fillers added to SACs in composition range between 60–75 wt% and is composed of barium fluoroaluminoborosilicate glass, strontium calcium aluminosilicate glass, quartz, colloidal silica and other glass fillers. The acid-soluble glass fillers provide for the neutralization of resin acidity and release of sodium, calcium, silicate and fluoride ions that either take part in the setting reaction or are released locally. The fillers determine the physical behavior and mechanical properties of cement.

The filler content of SACs is less compared with that of compomers. **(Sumit Makkar, Neeraj Malhotra, 2013)**

II.C Cavity liners:

Materials are placed with minimal thickness, usually less than 0.5 mm, and provide some type of therapeutic benefit, such as fluoride release, dentinal seal through adhesion to tooth structure, and/or antibacterial action that promotes pulpal health. **(McCoy RB,1995)**

II.D Cavity Bases:

It is a layer of insulating and medicating cement, placed in the deep portion of the tooth preparation to protect the pulpal tissue from thermal and chemical injury. Bases are applied in thick layers and must be strong enough to support a restorative material during its placement and function, and should offer thermal and electrical protection (from galvanic activity) to the pulp. Bases categorized into two groups, the first one is low-strength bases of CaOH or ZOE cements, which are referred to as liners; the second is high-strength bases zinc phosphate, polycarboxylate, and zinc oxide cement **(Anusavice, Ferracane, 2003)**.

II.D.1. Zinc phosphate cement

Zinc phosphate is the oldest of the luting cements and thus serves as a standard with which newer cements can be compared. The terms 'Crown and Bridge' and 'Zinc Oxyphosphate' have been used for this cement.

composition: Powder :zinc oxide (reactive component) and other oxides like magnesium oxide.

The liquid: is essentially composed of phosphoric acid, water, aluminum phosphate, and sometimes zinc phosphate **(Cornelis H Pameijer; 2016)**.

Advantages:

1. Easy to manipulate.
2. High strength necessary for a base.
3. Withstand mechanical trauma.
4. Provide good protection against thermal shock

Applications

1. Luting of restorations (inlays, crowns, fixed dental prostheses, etc.)
2. Luting of orthodontic bands and brackets.
3. As a base material when high compressive strength is required.
4. Sometimes used as a temporary filling material.

(Jabri et al., 2012).

-Mixing method

Mixing of the material should be performed on a cold glass slab. This promotes cooling of the exothermic reaction that occurs when the powder and liquid are combined and allows the clinician to incorporate more powder with the liquid, thus increasing the physical properties. Since the cement is placed on and in prepared teeth when it is in a “wet consistency” and not all the liquid has reacted with the powder, unreacted phosphoric acid liquid with a low pH ± 1.5 comes in contact with the preparation and causes an immediate (within 5 s) dissolution of the smear layer and smear plugs. Since cementation can cause a considerable amount of hydraulic pressure, the unreacted acid is pressed in the dentinal tubules and, depending on the remaining dentin thickness (RDT), the distance from the floor of the preparation to the pulp, can cause greater or less irritation to the pulp. Therefore, the pulp has to cope with not only heat but low acidity as well. The greater the RDT, the more beneficial the buffering action of the fluid in the dentinal tubules is and the less the effect of the acid. Furthermore, a greater RDT also diminishes the thermal effect. **(Cornelis H Pameijer; 2016).**

II.D.2_ Poly carboxylate cement:

Canadian biochemist Smith developed the first polycarboxylate cement in 1968 by substituting the phosphoric acid of zinc phosphate cement with polyacrylic acid. Polycarboxylate became the first cement system developed with potential for adhesion to tooth structure.

Composition: -

Powder: Zinc oxide, Magnesium oxide, -Strontium Chloride, Tannic acid,

Liquid: Poly acrylic acid.

Properties

- 1- Poly carboxylate cement is one of the dental cement systems which have chemical adhesion to enamel and dentin, by the ability of the carboxylate groups in the cement molecule to chelate to calcium in enamel and dentin.
- 2- The large sizes of the polyacrylic acid molecule, which can't penetrate through dentinal tubules, make this cement low irritant to the pulp, so this cement is used as a base or for cementation with sensitive teeth.
- 3- Setting time is about 5-6 minutes.
- 4- This cement is sensitive to disintegration and solubility more than zinc phosphate cement. **(Randy weiner, 2003)**

Application:

- 1-Cementation of crowns, bridges, inlays and orthodontic brackets.
- 2-Cavity lining under all restorative materials.
- 3-Used for temporary fillings such as direct or indirect pulp capping, the cement causes little or no pulp irritation, even when applied on freshly cut dentine. **(Pyrax, 2012).**

-Mixing method

Fluff the powder by Shaking powder bottle before use, dispense 1 spoon full of powder and level the powder to the edges of the spoon and 3 drops of bubble free liquid on a glass mixing slab or mixing pad at room temperature ranging from 21- 25 °C at relative humidity 50±10%, divide dispensed powder into 3 parts introduce each part of powder with dispensed liquid and mix it with short and quick strokes using a plastic or metal spatula until homogeneous mix is obtained. Total mixing time should not exceed 60 seconds. Thoroughly rinse the tooth surface with water and gently air dry.

If there is an exposure or near exposure of the pulp, apply calcium hydroxide over the exposure before using the cement, then apply thin layer of Polycarboxylate cement over the tooth structure. For cementation of metal crowns and PFM, Polycarboxylate cement must be allowed to set while metal and prepared tooth surfaces are compressed together ,

For this it is advised that the patient bites hard onto a cotton ball without periodic relaxation. Biting hard will remove excess cement and reduce its film thickness and improve the bond (**pyrax, 2012**).

II.D.3 Calcium hydroxide cement (CaOH)

Calcium hydroxide has been considered as gold standard for a long time and enjoys the greatest popularity among general dentists. In clinical practice, calcium hydroxide has been reported as liner of choice in patients with deep cavities. (**Aljanakh M et al, 2016**).

-composition:

Calcium hydroxide cements are paste/paste systems. One paste contains calcium hydroxide and the other contains salicylate. Salicylate is a weak acid that is chemically similar to eugenol and reacts with the calcium hydroxide. The acid–base reaction between calcium hydroxide and salicylate is responsible for setting, the reaction forms an calcium disalicylate. (**Sakaguchi RL, Powers JM, 2012**)

-Properties:

- 1- The set material has an alkaline PH (9.2-11.7), which reduces the acidity of zinc phosphate when used as a sub base material in deep cavities.
- 2- The antimicrobial action of calcium hydroxide makes this material useful in indirect pulp capping procedures.
- 3- Calcium hydroxide stimulate the odontoblast cells for the formation of secondary dentin (stimulate the formation of dentinal bridge) when it is put directly over exposed pulp tissue, so calcium hydroxide is used for direct pulp capping.
- 4- Water is important component for the setting reaction of calcium hydroxide-based liner.

Application:

1. Pulp Capping Agent.
2. Apexification procedure in young permanent teeth where root formation is incomplete.
3. Intracanal Medicament
4. Endodontic Sealer.
5. Pulpotomy.

Mixing method

The easiest method to prepare a calcium hydroxide paste is to mix calcium hydroxide powder with water until the desired consistency is achieved. (Alok Dubey, 2016).

II.D.4 Zinc-Oxide Eugenol Cement

These cements have been used extensively in dentistry since the 1890s. Depending on their use they vary widely in their properties. In general, they are cements of low strength. They are the least irritating of all dental cements and are known to have an obtundent (sedative) effect on exposed dentin. (JOHN J MANAPPALLIL , 2016).

Composition:

Powder: Zinc oxide with the addition of white rosin to reduce the brittleness of the set cement, and zinc acetate to improve the strength of the cement.

Liquid: eugenol with olive oil as a plasticizer.

Properties

Said to be the least irritating of all dental materials. Despite having a pH of about 7 and having a sedative effect on the pulp, the eugenol can be toxic to the pulp, especially when present in high concentrations. It is for this reason that ZOE should not be placed in direct contact with the pulp. (Craig RG, Powers JM, 2002).

Uses:

1. As temporary restorations.
2. The modified type used as a crown and bridge cementation and as a cement base.
3. As an endodontic sealer.

* Zinc oxide eugenol Cement is unaccepted as base material under composite restorations because it impaired the setting reaction (polymerization) of composite resin.

Classification for zinc oxide eugenol cement

Type I—for temporary cementation

Type II —for bases and temporary restorations

The previous version of this classification listing 4 classes, has been replaced only 2 classes.

Type I cements are meant for short term luting (1-6 weeks). They are used to cement provisional restorations for the period it takes to make the definitive restoration.

Type II cements are used for the interim period (few weeks to few months) when a tooth is undergoing treatment or until it is ready for a permanent restoration. They can also be used as bases under non-resin based permanent restorations.

Mixing method

The preferred technique for mixing ZOE is adding the powder to the liquid a little at a time using vigorous spatulation .The resulting material is not exothermic, but clinicians should be aware of ambient conditions, as a humid environment could cause the reaction to speed up. As the powder: liquid ratio is increased, the mix becomes drier and less tacky. The resultant mixture is easier to work with and contains less free eugenol to irritate the pulp. (**Randy Weiner, 2011**) ZOE is not marketed as a cavity liner, but as a base. Some products contain polymethylmethacrylate, which is incorporated in order to strengthen the material, making it more appropriate for use as a cavity base.

Considered a low strength base by (**Craige, powers, 2002**)

II.D.5 Glass Ionomer Cements (GIC):

Glass ionomer cements are adhesive tooth-colored anticariogenic restorative materials which were originally used for restorations of eroded areas. Current glass ionomers have been modified to allow a wider application. These cements evolved from a general dissatisfaction with silicate cements. The first usable glass ionomer system was formulated in 1972 by Wilson and Kent and was known as ASPA. Subsequently great improvements were made and today these materials are very popular and

widely used. It was named glass ionomer because, the powder is a type of glass and the setting reaction and adhesive bonding to tooth structure is due to ionic bond. Unlike other restorative materials, this cement requires minimal cavity preparation as it bonds adhesively to tooth structure. Compared to composite resin they are less technique sensitive. Glass ionomer cement is often known as a biomimetic material, because of its similar mechanical properties to dentine. For this reason it is one of the most popular cements in dentistry. (JOHN J MANAPPALLIL , 2016)

Synonyms

- Poly (alkenoate) cement
- GIC (glass ionomer cement)
- ASPA (alumino silicate polyacrylic acid)

Composition

Powder is an acid soluble calcium aluminosilicate glass containing fluoride. It is formed by fusing silica + alumina + calcium fluorite, metal oxides and metal phosphates at 11000-15000 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 –50µm size depending on what it is going to be used for. They are decomposed by acids due to the presence Al +3 ions, which can easily enter the silica network. (TR. Mahesh Singh et al, 2011).

Functions of components:

Alumina (Al₂O₃)

- Increase opacity

Silica (SiO₂)

- Increase Translucency

Fluoride: Its has 4 functions:

- Anticariogenecity
- Increase translucency
- Increase working time
- Increase strength

Calcium fluoride (Ca F₂)

- Increase opacity
- Acts as flux

Aluminium phosphates

- Decrease melting to
- Increase translucency

Liquid :The liquid is composed of polyacrylic acid and tartaric acid, the latter to accelerate the setting reaction. The reaction of the powder with the liquid causes decomposition, migration, gelation, postsetting hardening and further slow maturation. The polyacrylic acid reacts with the outer surface of the particles resulting in release of calcium, aluminum, and fluoride ions. When a sufficient amount of metal ions has been released, gelation occurs, and hardening continues for about 24 hours. (**A. D. Wilson and B. E. Kent, 1971**).

APPLICATION

1. Anterior esthetic restorative material for Class III cavities.
2. Restorative material for eroded areas and Class V restorations
3. As a luting agent for restorations and orthodontic brackets.
4. As liners and bases.
5. For core build up.
6. To a limited extent as pit and fissure sealants.
7. Intermediate restorative material.
8. Atraumatic restorative treatment (ART) technique.

Glass ionomer cements are not recommended for Class II and Class VI restorations, since they lack fracture toughness and are susceptible to wear.

Properties of GIC:

1. Adhesion: Adhesion of GIC helps in:

- a) Providing a conservative approach to restorations
- b) Providing a perfect seal.

2. Biocompatibility: Adverse effect of GIC on living tissues is 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:

- a) PAA is a weak acid, which becomes weaker when partly neutralized
- b) Its diffusion into the tubular dentin is unlikely due to its high molecular weight and heavy chain entanglement
- c) It is readily precipitated by the calcium ions in the tubules.

3. Anticariogenicity :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

- a) Physicochemical mechanism.
- b) Biologic mechanism.

4. Aesthetic :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. **(TR.Mahesh Singh et al, 2011).**

5. 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 occurs. **(TR. Mahesh Singh et al, 2011).**

6. 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. (**TR. Mahesh Singh et al, 2011**).

7. 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. (**TR. Mahesh Singh et al, 2011**).

Classification of glass ionomer cement:

The most practical classification of the Glass ionomer cements is on their clinical usage into:

Type I Glass ionomer cements are the luting cements, characterized by low film thickness and rapid set.

Type II Glass ionomer cements are restorative cements, with sub-types into two types.

Type II-1 Glass ionomer cements are aesthetic cements (available in both conventional and resin-modified presentations) and **Type II-2** Glass ionomer cements are 'reinforced' cement which are more wear-resistant.

Type III Glass ionomer cements are the lining cements and fissure sealants, characterized by low viscosity and rapid set.

II.D.6 Resin Modified Glass Ionomer Cement

These are relatively new materials having various names like compomer, resin-ionomers, RMGI (resin-modified glass ionomer), light cured GIC, dual cure GIC, tricure GIC, reinforced GIC, hybrid ionomers, etc. These materials were developed to overcome some of the drawbacks of conventional GIC like :

1. Moisture sensitivity

2. Low initial strength
3. Fixed working times.

Uses

1. Restoration of Class I, III or V cavities.
2. Bases and liners.
3. As adhesives for orthodontic brackets.
4. Cementation of crowns and FDPs.
5. Repair of damaged amalgam cores or cusps.
6. Retrograde root filling.

Note: Uses vary according to brand.

SUPPLIED AS

They are supplied as

- Chemical cure (acid-base setting reaction of the glass ionomer portion).
- Dual cure (combines acid-base setting reaction of the GIC portion and light curing of the resin portion).
- Tricure (combines acid-base setting reaction, chemical and light cured polymerization of the resin portion).

All of them are usually supplied as powder and liquid. The light cured type is supplied in dark shaded bottles (for light protection).

II.D.7 Glass Carbomer:

One of the most important recent advances in dentistry is the application of nanotechnology. (**Rastelli et al, 2012**) described nanotechnology as “the production and manipulation of materials and structures with particles size in the range of about 0.1 – 100 nm by various physical or chemical approaches” providing an aesthetically acceptable restoration with excellent mechanical properties. These interesting advances led to the

development of glass-ionomer based filling material called glass carbomer cement (CAR). (**Olegário IC et al, 2015**).

Glass carbomer cement (CAR) contains nanosized powder particles and hydroxyapatite (HAp) and fluorapatite (FAp) as secondary filler and has been introduced with claims of improved physical characteristics in comparison with conventional GIC. (**Goldman AS et al, 2014**).

It sets by an acid-base reaction between an aqueous polymeric acid and an ion-leachable basic glass, though it also contains substances that are not usually included in glass-ionomer formulations. (**Cehreli, S.B et al, 2013**).

These components are as follows:

1. A glass powder that has been washed by strong acid so that the surface layers of the particles are substantially depleted in calcium (**Van Duinen et al, 2004**). Hence, most of calcium ions lie well inside the particles towards the core.
2. A silicone oil comprising a polydimethylsiloxane generally of linear structure, which contains hydroxyl groups. This allows the silicone oil to form hydrogen bonds with other components of the cement, so that it remains bound in the cement after setting.
3. A bioactive component: which also behaves as secondary filler. Solid-state spectroscopy has shown that this filler is actually hydroxyapatite and it is included to promote the formation of enamel-like material at the interface with the tooth, as observed previously with conventional glass ionomer fissure sealants. (**Zainuddin et al, 2012**).

Due to the acid-washing process, the glass is unreactive towards poly (acrylic acid) or acrylic/maleic acid copolymer. In addition, the silicone oil incorporated into the glass powder becomes adsorbed onto the surface of the glass, and this also interferes with the reaction with polyacid. As a result, the glass carbomer is easy to mix at high

powder: liquid ratios and only a little reaction occurs as these two components are blended.

Once the material is mixed, its sluggish setting reaction is speeded up by the application of a dental cure lamp for at least 20s. This is not to promote photo-polymerization, but because dental cure lamps give out heat. This increases the temperature of the cement, causing it to set in a reasonable time. **(Cehreli, S.B et al, 2013).**

Glass carbomers contain high proportions of glass compared with conventional glass-ionomers, and hydroxyapatite filler, so that the set glass carbomer would be very brittle. To overcome this, the silicone oil is added. It toughens the material, and remains bound within the material by hydrogen bonding. **(Sidhu and Nicholson, 2016).**

II.E Newer advances of Glass Ionomer Cement

Conventional GIC lacks sufficient strength and toughness, which has attracted focused research. In order to improve the mechanical properties of conventional GIC, Resin-modified glass-ionomers (RMGI) were introduced, that contains hydrophilic monomers and polymers like HEMA and they have higher flexural strength compared to conventional GIC. **(Nagaraja , Kishore G, 2005).**

Recently, a new restorative concept is marketed, a system application consisting of a posterior restorative GIC combined with a novel nanofilled coating material, the compounded nanofillers protect against the abrasive wear and the coating acts as a glaze, enhancing its esthetic properties. **(Hench LL, 2006).**

Hybridization of GIC and Composites using pre-reacted glass ionomer technology, 'Giomers' was developed by Shofu. **(Wilson AD, 1991).**

Newer bioreactive material 'HAINOMER' was developed using hydroxyapatite with glass powder and have shown a promising future during initial clinical trials as retrograde filling material. More recently, Zirconia containing GIC, Proline containing GIC, CPP-ACP GIC are synthetically manufactured to enhance the remineralization potential and aimed at improving the strength. **(Manvi Malik et al, 2015).**

References

- Aljanakh, M., et al.,(2016),” Do dentists in Ha’il region follow contemporary pulp protection protocols? A Saudi based study”, *Int J Dent Sci Res*,2016;4(4):68– 71.
- Anusavice, K.,(2003),”Phillip’s Science of Dental Materials”, 11th edn.Philadelphia: WB Saunders.
- Burgess, J.,O., et al., (2010),” Self adhesive resin cements *J Esthet Restor Dent* “2010; 22: 412–419.
- Cehreli, S., B., et al.,(2013),” Microleakage of newly developed glass carbomer cement in primary teeth”, *Eur. J. Dent.* 2013, 7, 15–21.
- Craig, R., G., (2002),” Powers JM. *Restorative Dental Materials*”, (11th edn). St Louis: Mosby; 2002.
- Duinen,V,W.,& Duinen,V., R.,N.,(2004),” Self hardening glass carbomer composition”, US Patent 20060217455 A1, 2004.
- Ferracane, J., L., (2001),” *Materials in dentistry: principles and applications*”, 2nd edn. Philadelphia: Lippincott Williams and Wilkins.

- Goldman, A., S., et al.,(2014),” Methods and preliminary findings of a cost- effectiveness study of glassionomer- based and composite resin sealant materials after 2 yr”, Eur J Oral Sci. 2014; 122(3) : 230–237.
- Hench, L.,L.,(2006),(2006),”The story of Bioglass”, J. Mater sci 2006;17;11:967-78
- Heymann, H., et al., (2013),”Sturdevant’s Art and Science of Operative Dentistry”, 6th ed, St Louis: Elsevier/Mosby; 2013.
- Malik,M., et al.,(2015),” Composition and Biocompatibility of GIC’s with future horizons: An Insight”,Journal of Dental Herald 2015:1:2:7-10.
- Manappallil, John J. Basic Dental Materials. New Delhi ; Philadelphia, Jaypee Brothers Medical Publishers (P), Ltd, 2016.
- Olegário, I.,C.,et al.,(2015),” Mechanical properties of high- viscosity glass ionomer cement and nanoparticle glass car-bomer”, J Nanomater. 2015; 2015: 37.
- Pameijer, C., H., (2016),” Biocompatibility of Luting Cements for Dental applications”, International Journal of Dentistry, Volume 2012, Article ID 752861, 7 pages.

- Pegoraro, et al., (2007),” Cements for use in esthetic dentistry”, Dental Clinics of North America. 2007; 51:453-471.
- Rastelli, A.,N., et al.,(2012),” The filler content of the dental composite resins and their influence on different properties”, Microsc Res Tech. 2012; 75: 758- 65.
- Ritter, A.,V.,& Swift, J.,r., E.,J., (2003),” Current restorative concepts of pulp protection”, Endod Top, 2003;5(1):41–48.
- Royse, M., C., et al.,(1996),” Dentin adhesive superior to copal varnish in preventing microleakage in primary teeth”. Pediatric Dent 1996; 18:440–443
- Sidhu,S.,K.,& Nicholson,J.,W.,(2016),” A Review of Glass-Ionomer Cements for Clinical Dentistry”, Journal of Functional Biomaterials, ISSN 2079-4983.
- Singh,T.,M.,(2011),” Glass IONOMER CEMENTS (GIC) IN DENTISTRY: A REVIEW”, International Journal of Plant, Animal and Environmental Sciences Page: 2.
- Upadhya,N.,& Kishore,G.,(2005),”Glass IonomerCement - Different generations, trends”, J. biomater artif organs 2005:18:158-65.
- Wilson, A.,D.,(1991),” Glass Ionomer Cement-Origin, development and future”, J. Clin mater 1991:7:4:275-82.

- Wilson,A., D., & Kent ,B., E., (1971), “The glass-ionomer cement:a new translucent dental filling material,” Journal of AppliedChemistry and Biotechnology, vol. 21, p: 313, 1971
- Yu, H., et al., (2014)” Proper selection of contemporary dental cements” Oral Health Dent Manag, 13(1):54-59.
- Zainuddin,N.; et al.,(2012),” Characterisation of remineralising Glass Carbomer® ionomer cement by MAS-NMR spectroscopy”, Dent. Mater. 2012, 28, 1051–1058.