ORIGINAL RESEARCH PAPER

Dentistry

LUTING CEMENTS : REVIEW

KEY WORDS: Phosphate, Polycarboxylate, ZOE, GIC, Compomer, Adhesives, Resin cements.

Dr. Seema.Hanjagi	Postgraduate Department of conservative dentistry and endodontics Maratha Mandal's Nathajirao. G. Halgekar Institute of Dental Sciences& Research
Dr.Pallavi Gopeshetti*	Professor, Department of conservative dentistry and endodontics Maratha Mandal's Nathajirao. G. Halgekar Institute of Dental Sciences& Research *Corresponding Author
Dr. Madhu Pujar	Professor and Head of theDepartment of conservative dentistry and endodontics Maratha Mandal's Nathajirao. G. Halgekar Institute of Dental Sciences& Research
Dr Divyashree D	Postgraduate Department of conservative dentistry and endodontics Maratha Mandal's Nathajirao. G. Halgekar Institute of Dental Sciences& Research

ABSTRACT

Long-term clinical success of restorations is influenced by many factors, one important factor being the selection of an appropriate luting agent .No single luting agent is capable of meeting all the stringent requirements, which is one reason why there is such a wide choice of luting agents currently available from conventional water-based to contemporary adhesive resin cements. Various types of cements have been used for luting over past 100 years such as, zinc phosphate, zinc silicophosphate, zinc polycarboxylate, glass ionomer, and zinc oxide eugenol. It is important to understand various cements, their advantages and disadvantages. The primary purpose of the luting procedure is to achieve a durable bond and to have good marginal adaptation of the luting material to the restoration and tooth. Conventional cements have always relied upon retention and resistance forms in tooth preparations; Adhesive-type luting agents offer the clinician an added advantage by bonding to the tooth structure. In recent years, many luting cements have been introduced claiming better performance clinically than existing materials due to improved characteristics. There are innumerable cements present with different properties, one should know all the properties to use it in order to give a successful restoration to the patient.

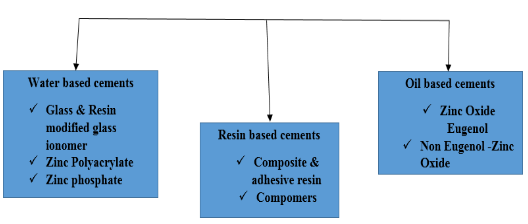
1. INTRODUCTION :

Numerous dental treatments necessitate attachment of indirect restorations such as crowns , bridges , inlays , onlays including metal, resin, metal-resin, metal ceramic, and ceramic restorations, orthodontic appliances; and pins and posts to the teeth by means of a cement.

Luting agent is defined as any material used to attach or cement indirect restorations to prepared tooth.

Various types of cements have been used for luting over past 100 years such as, zinc phosphate, zinc silicophosphate, zinc polycarboxylate, glass ionomer, and zinc oxide eugenol. The current trends seem to be towards the development of better mechanical bonds at the microscopic levels through pre-treatment of the surfaces with various conditioning agents. Now the dental professionals continue to seek new adhesive characteristics to improve the traditional materials. There is also a growing market for resin adhesive technologies Currently.[1]

2. Craig classifies luting cements as follows :[2]



3. ZINC PHOSPHATE CEMENT:

Zinc phosphate cement is the oldest of the cementation agents and thus has the longest track record. It is a traditional crown and bridge cement used for the alloy restorations.

Commercially available products include:

- Fleck's Zinc (Mizzy),
- Hy-Bond (Shofu), and
- Modern Tenacin (LD Caulk). [1]

The main component of powder is zinc oxide with 2–10% of magnesium oxide. Liquid is essentially an aqueous solution of phosphoric acid (45–64%) buffered by adding small quantities of zinc oxide/aluminium oxide. Water content of liquid (30–55%) is significant because it controls ionization of acid, which influences the rate of setting reaction. Loss of water can lengthen the setting reaction and vice versa. Water evaporation should be suspected if the liquid appears cloudy on dispensing.[1]

When the powder is mixed with the liquid the phosphoric acid attacks the surface of the particles and releases zinc ions into the liquid. Thus the set cement is a cored structure consisting primarily of unreacted zinc oxide particles embedded in a cohesive amorphous matrix of zinc aluminophosphate.[2]

Frozen Slab Method

The frozen slab method is a way to substantially increase the working time of the mix on the slab and shorten the setting time. In this method, a glass slab is cooled in a refrigerator below freezing point.[3] Zinc phosphate cement is used most commonly for luting permanent metal restorations and as a base.

Other applications include cementation of orthodontic bands and the use of cement as a provisional restoration. The film thickness of the zinc phosphate cement greatly determines the adaptation of the casting to the tooth and also determines the strength of the retention bond.

The maximum film thickness is 25 m. the heavier the consistency; the greater the film thickness and the less complete the seating of the restoration.[1]

4. Zinc Silicophosphate Cement

They are also called as Zinc silicate, Silicate zinc cement and was introduced in 1878. Powder is a combination of zinc oxide and silicate glass (contains 12–25% fluoride) and liquid is concentrated phosphoric acid. The cement does not bound to tooth structure; hence retention is by mechanical interlocking.

The use of Zinc silicophosphate cement is declining, as practitioners have choice of other more aesthetically pleasing materials such as resin and glass ionomer cements. They are used as luting agents for restorations and orthodontic bands, intermediate restorations and as die material. The flow property of the mix is not as good as zinc phosphate cement, leading to higher film thickness. The cement does not bound to tooth structure; hence retention is by mechanical interlocking.[3]

5. Zinc Polycarboxylate Cement

In the quest for an adhesive cement that can bond strongly to the tooth structure, Zinc polycarboxylate cement was the first cement system that developed an adhesive bond to tooth structure in 1960 was developed by Dr. Dennis Smith, a Manchester dentist in 1968 as a basic set of two liquids and one powder. One liquid was used for luting purpose, while the other for lining purpose. He replaced phosphoric acid with a new polymeric acid, polyacrylic acid and it was the first chemically adhesive cement.

The powder contains 4% stannous fluoride but it does not impart any anticariogenic property because fluoride released is only 10–15% of that released by the glass ionomer cement. However, it acts as a strengthening agent.[3]

The hardened cement consists of an amorphous gel matrix in which unreacted particles are dispersed. The microstructure resembles that of zinc phosphate cement in appearance.[4] Zinc polyacrylate cements are used primarily for luting permanent alloy restorations and as bases. Theses cements have also been used in orthodontics for cementation of bands .The initial viscosity of zinc polycarboxylate cement is higher than zinc phosphate cements and a delay of 2 minutes in cementation reverses the situation. Since zinc polycarboxylate cement is pseudo plastic cement it undergoes thinning at an increase shear rate. Clinically, this means that the action of spatulation and seating with a vibratory action will reduce the viscosity and yield a film thickness of 25- m or less.[1]

6. Zinc-Oxide Eugenol Cement (ZOE)

Zinc oxide eugenol cement was developed by Dr. J. Foster Flagg in 1875. This cement was developed from zinc oxychloride cement by substitution of the liquid with, first creosote, then eugenol. The first proprietary ZOE product was "pulpol", introduced by Wessler in 1894.

Various additives have been combined with zinc oxide eugenol cement to improve its strength and reduce solubility, example, silica, alumina, rosin, dicalcium phosphate, polystyrene, polymethylmethacrylate, and ortho-ethoxybenzoic acid (EBA)

The setting mechanism for ZOE material consists of zinc oxide hydrolysis and a subsequent reaction between zinc hydroxide and eugenol to form a chelate.[3] ZOE cements are used as a luting material for provisional restorations in crown and bridge prosthodontics. The film thickness should not be more than 25 m for cements used for permanent cementation and not more than 40 m for cements used for temporary cementation.[1]

6. GLASS IONOMER CEMENT : (GIC)

A new translucent cement was developed by Wilson and Kent 1969 based on acid–base reaction between aluminosilicate glass powder and an aqueous solution of polymers and copolymers of acrylic acid, including itaconic, maleic, and tricarboxylic acid. Glass-ionomer cement has been defined by McLean, Nicholson and Wilson as the "cement that consists of a basic glass and an acidic polymer which sets by an acid–base reaction between these components'. The word 'Ionomer' was coined by the Dupont Company to describe its range of polymers containing a small proportion of ionized or ionisable groups, generally of the order of 5–10% .[3]

Chief concern with this cement is, when a freshly mixed cement is exposed to ambient air without any protective covering, the surface will craze and crack as a result of desiccation, leading to cohesive failure from micro crack formation. When the excess cement extruded around the margins has become doughy, covering it with petroleum prevents it from dehydrating. Avoid over desiccation as it increases the incidence of post-operative sensitivity.[4]
It is indicated in exposed porcelain margins used for cosmetic reasons, because of the increased translucency and for Crown & other prosthesis cementation, because of its ability to release fluoride, as there is a risk of secondary caries in crown cementation and Chemical bonding. The glass ionomer cement is capable of forming films of 25 m or less. Glass ionomer cements bond well to enamel, stainless steel, and tin oxide plated platinum and gold alloy. Bonding is of a chemical rather than a micro mechanical nature. Therefore, no acid etching or surface roughening procedures is deprecated. About 80% of maximum bond strength is developed in 15 minutes but strength slowly increases for several days after that.[1]

8. Resin-Modified Glass-Ionomer Cements :

This cement was introduced in 1990s with an objective to combine some of the desirable properties of glass-ionomer cements (fluoride release and chemical adhesion) with high strength and low solubility of resins. Announce et al. originally used the term resin-modified glass-ionomer as the trivial name and resin-modified glasspolyalkenoate as the systematic name.

Polymerizable functional groups were added to the conventional glass-ionomer cements to achieve rapid curing activated by light/chemical while still allowing acid– base reaction to take its course along with the polymerization. Wear resistance was also improved.

Chemically-activated polymerization of the resin-modified glass-ionomer cement is referred to as "Dark Cure". These cements can be chemical-cured, light-cured, dual cured or tri-cured Polyacrylic acid attacks Fluoro alumino silicate glass (base) to form calcium and aluminium poly salt hydrogel. The second reaction is the polymerization of HEMA to Poly HEMA. Water sorption is higher than resin cements. Fluoride release is similar to glass ionomer cements.[1]

Hybrid ionomer cement are indicated for permanent cementation of porcelain fuse to metal crowns, bridges, metal inlays, on lays, and crowns, post cementation and luting of orthodontic appliances. Additional uses include adhesive liners for amalgam, bases, provisional restorations and cementation of specific ceramic restorations. The fracture toughness is higher than that of other water based cements but lower than composite cements. The bond strength to moist dentin ranges from 10 to 14 MPa and is much higher than that of most water based cements. Hybrid ionomer cement have very low solubility when tested by lactic acid erosion. Water sorption is higher than resin cements.[1]

9. RESIN CEMENTS :

Resin cements are composites composed of a resin matrix, e.g bis-GMA or urethane dimethacrylate, and a filler of fine inorganic particles. Resin luting cements differ from restorative composites primarily in their lower filler content and lower viscosity. Composite resin cements are available as self-cured, light cured and dual cured materials. The self-cured materials are typically used as luting cements because of the inability, or at best difficulty, of light to pass through porcelain and metal restorations. Examples include Panavia, All Bond 2 luting cement and Super bond.

Problems with the use of resin cements for luting full crowns include excessive film thickness with some materials, marginal leakage because of setting shrinkage, and severe pulpal reactions when applied to cut vital dentine.[1]

TABLE 1: PROPERTIES OF VARIOUS CEMENTS.[3]

CEMENTS	Film thickness (lm)	Solubility (wt.%) in water at 24 h	Setting time (min)	Working time (min) at room Temp.	Strength (MPa) Compressive	Tensile	Elastic modulus (GPa)	pH 2 min	pH 24 Hr.
Zinc phosphate	25	0.2%	5-14	3-6	80-110	5-7	13	2.14	6
Copper phosphate	20	0.2-0.3	5-7		80-85			High	
Silicophosphate	88	1	2-10	3-4	140-170	7-11		1.4	5.5
Zinc oxide eugenol	25-35		7-9	Long, moisture Needed for setting	2-14	0.3-2	0.22	Mild	7
Polymer reinforced	25	0.08	7-9		35-55	5-8	2-3	Mild	
EBA ALUMIN	25-40	0.2	6-9		55-70	3-6	3-6	Mild	
Zinc polycarboxylate	25-30	0.06	6-9	2.5-3.5	55-90	8-12	4-5	3.42	5.9
Glass ionomer	25	0.4-1.5	6-9	2-3.5	93-226	6-7	8-11	2.33	5.6
Resin modified glass ionomer	25	0.07-0.4	5.5-6	2-4	85-126	13-24	2.5-7.8		
Composite resin	25	0.13	4-5		180-265	24-37	4.8-6.5		
Adhesive resin	25				52-224	37-41	1.2-10.7		

Indicated for cementation of Feld spathic porcelain and Maryland bridges cements recommended for cementation of indirect restorations have a film thickness of 25 m or less. Water sorption and solubility of resin cements are much lower than those of resin-modified glass ionomer cements. With respect to bonding to dentin, the so-called adhesive cements, which incorporate the phosphate, HEMA or 4-META adhesion systems, generally develop reasonably good bond strengths to dentin. Bonding to tooth structure may be more critical for resin based cements than for some other types of cement, because they possess no anticariogenicity potential.[1]

10. RECENT ADVANCES

a) ANHYDROUS CEMENT :

Termed as ASPA Va by Prosser et al in 1984 a water hardening luting agent, means that the acid has been freeze dried and included in the powder. The polyacrylic acid can be vaccum dried and incorporated with GIC. The advantages are: Low viscosity in early mixing stage, rapid set at minimum temperature and easy manipulation[5].

b) CALCIUM ALUMINATE-GLASS IONOMER CEMENT

This material contains a mixture of monocalcium aluminate ($CaOAl_2O_3$), inert glasses and, in some cases, glass ionomer particles. Because of its calcium content and high pH, these cements were shown to be bioactive, promoting hydroxyapatite precipitation in vitro. Its performance in terms of mechanical properties and crown retention (metal and ceramic) is similar to self-adhesive cements. Because the aluminium hydroxide initially forms as an amorphous gel, excess removal is facilitated.

c) COMPOMERS :

Polyacid modified composite resins .Compomer can be defined as a resin composite with fluoride releasing Potential. Name derived from -COMPOSITE (COMPO) - and GLASS IONOMER (MER).

Compomer is the resin based cement indicated for cementation of cast alloy crowns and bridges, porcelain fused to metal crown and bridges and gold cast inlays and onlays. The cement should not be used as a core or filling material.[7]
Idea to introduce was to retain benefits of both while minimizing their respective disadvantages. In appearance and performance – closely related to composites than glass ionomer cements.[1]

d) X 200 DUAL CURE –ADHESIVE RESIN COMPOSITE CEMENT:

Like 3M ESPE Rely-X Clicker Luting Cement, Auto mix Resin-modified composite luting Cement in a capsule designed for adhesive luting of all ceramic, metal or composite indirect restorations including fibre posts. The mechanical properties are superior to those of zinc phosphate and glass ionomer cements with little risk of marginal gap formation.it is also distinguished by its unique moisture tolerance and little risk of postoperative sensitivity.

e) AUTOMIX TEMPORARY LUTING CEMENT NON EUGENOL :

A contemporary eugenol free zinc oxide based temporary luting cement. The catalyst and base pastes are presented in an automix syringe for accurate mixing and easy application. The material mixes reliably every time to a smooth creamy consistency. Excellent flow characteristics and quick setting reduces chair time it is a radiopaque material with low film thickness with excellent marginal adaptation.[8]

f) ALLOY PRIMER: is a metal conditioning agent used to enhance the bond strength between dental metals and resin base materials. Metal primer used to increase the bond strength of composite and acrylic resins to stainless, aluminium, steel and other dental alloy. Alloy primer enhances the adhesion between resin-base materials and dental metals (Non-precious metals as well as precious metals) Surface treatment is accomplished with just one coat of alloy primer.[9]

g) DENTAL NANO HYBRID COMPOSITE KIT:

'Nanohybrid' Composites: Incoporation of nanoparticles into composite formulations .A new resin composite with unique nanofiller technology. Formulated with nanocluster filler particles. Nanomers (5nm-75nm) & 'nanocluster' agglomerates (0.6 µm -1.4 µm) . Primary Zirconia/ Silica nanoparticles (5nm-20nm) fused; infiltrated with silane .Excellent adhesion to tooth structure and increased physical properties.[10]

h) SELF ADHESIVE CEMENT:

Developed for luting direct and indirect restorations, all-in-one resin luting cement is said to offer reliable bond strength, convenient application and reduced risk of post-operative sensitivity.

With the easy handling and moisture tolerance of classical cements and mechanical and aesthetic properties of resin luting cements, it can be used to etch, prime, bond and cement indirect restorations.[11]

I) JAPANESE ACRYLIC OR DUAL AFFINITY RESINS:
Whose manufacturer claims that they have ability to combine with both metal and tooth chemically these cements contain adhesive monomer like MDP, HEMA, and 4META.
Eg.PANAVIA (j morita) contain MDP and METABOND (paskels)
These cements providing increased retention to the restoration when minimal retention form exist.

PANAVIA SA CEMENT: is a dual cure fluoride releasing cement that comes in either a simple automixing system or hand mixing system. It eliminates the complexity of multi bottle systems. It has increased adhesion performance.it is simply applied to the restoration surface after adequate pre-treatment through air –particle abrasion (zirconia) or acid etching (silicate cements) The different types available are: PANAVIA 2.0, PANAVIA F 2.0, and PANAVIA V5

PANAVIA SA PLUS AUTOMIX CEMENT: is a dual cure, self-etch, self-adhesive resin cement that provides fluoride release. Provides an outstanding level of adhesion to enamel, dentin, metal lithium disilicate and zirconia.it provides improved bond strengths to natural teeth and all materials such as lithium silicates, and zirconia. It has high concentration of MDP to provide high bond strength to zirconia an natural teeth without additional surface treatment.

11. Clinical procedure:

CHOICE OF LUTING CEMENT : The decision on what cement to use depends mainly on two factors, the restoration material and the amount of retention needed. When the fit of the crown is considered satisfactory and all adjustments have been made, the crown can be cemented.

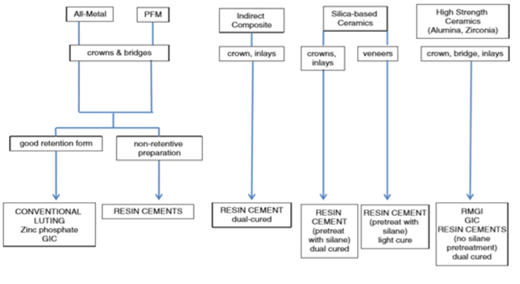


FIGURE 1: CHOICE OF LUTING AGENT1

12. CROWN CEMENTATION PROCEDURE:

When a crown has been successfully tried-in and the cement chosen, cementation may then take place. Isolate the preparation and ensure good moisture control. If the gingivae have overgrown the finish line use either retraction cord with haemostatic agent or if more severe use electrosurgery or lasers.[1]

Clean the preparation and crown with water spray ,Air dry but do not desiccate preparation and Mix cement according to manufacturer's instructions then Coat the fit surface with cement - do not overfill , Only apply cement to preparation if cementing a post. Lentulo spirals are used to load the cement in post space. Luting agent fills the dead space in root canal, post core is inserted gently to avoid hydrostatic pressure .13
The crown should be seated quickly with firm finger pressure until all excess cement has been expressed from the margins. Force must be adequate to ensure complete seating, but sudden excessive force may result in elastic rebound and the crown being partly dislodged.

Adequate moisture control should be maintained until the cement has set to prevent moisture contamination of the unset material at the crown margin. In the case of conventional cements, excess cement should be left until the cement sets. Following clean up, a final evaluation of the cemented crown can be made including rechecking the occlusion. 14

13. LUTING OF VENEERS :

All ceramic restorations may be cemented with zinc phosphate, glass ionomer or dual polymerizing resin cement. Pretreatment of Tooth Structure and Pretreatment of the Internal Surface of the Restoration is done. Clean the prepared tooth with non fluoride pumice and try in the porcelain veneers. Verify the marginal fit. A drop of water or glycerin will help the veneer stay in place. The restoration should be internally clean, etched and silaned.[13]

The rst procedure is done through air abrasion, sandblasting, or etching with a hydro uoricacid (for ceramic and composite restorations) or application of an alloy primer (for restorations with a metal subsurface). The second procedure is achieved by applying a silanating agent on the etched porcelain or composite. Dispense equal amounts of base and catalyst from dual cure resin and Mix for 10-20 seconds. Apply a thin layer of cement to the internal surface of the crown. Seat the crown and remove excess cement from the marginal areas with an explorer and clean brush.[14]

Silica based ceramics (feldspathic , leucite – reinforced and lithium silicate) should always be resin bonded and treated with acid etching and silane coupling agent application. High strength , metal oxide based ceramics such as alumina and zirconia are considered cementable , due to their high flexural strength. Air-particle abrasion with $Al2O3$ is both effective and practical to provide long –term durable bond strengths to high strength ceramics.

The tack and wave technique introduced by Dr. David Hornbrook is one method of light curing cements under veneer restorations. In this technique, the restorations are seated on the teeth and cured for 1second on the center with a small-diameter light guide. The restoration is cured again, this time with a larger diameter light guide waved about one inch from the restorations for an additional 3seconds, allowing the cement to establish a "semi-gel state."[2]

14. CONCLUSION:

Luting agents possess varied, complex chemistries that affect their physical properties, longevity in clinical situations. Though cements are used in small quantities in oral cavity, it should be used with at most care, as it is very important. There are innumerable cements present with different properties, one should know all the properties to use it in order to give a successful restoration to the patient Improved laboratory and clinical characterization of cements should lead us to the goal of an adhesive biocompatible cement that will last as long as the restoration.Dentist must be aware of the virtues and shortcomings of each cement type and select them appropriately.

REFERENCES

1. A Practical Clinical Guide to Resin Cements -Michelle ,Sunico-Segarra .
2. Craig :Restorative dental materials. 12th Edition
3. Anusavice: Phillips science of dental materials 11th Edition.
4. Smith DC. Development of glass-ionomer cement systems. Biomaterials. 1998 Apr 1;19(6):467-78.
5. Moshaverinia A, Roohpour N, Chee WW, Schricker SR. A review of powder modifications in conventional glass-ionomer dental cements. Journal of materials chemistry. 2011;21(5):1319-28.
6. Tan Y, Liu Y, Birdi G, Grover LM, Li H, Li K. Calcium silicate/calcium aluminate composite biocement for bone restorative application: synthesis, characterisation and in vitro biocompatibility. Advances in Applied Ceramics. 2016 Oct 2;115(7):384-90.
7. Moodley D, Grobler SR. Compomers: adhesion and setting reactions. SADJ: journal of the South African Dental Association= tydskrif van die Suid-Afrikaanse Tandheelkundige Vereniging. 2003 Feb 1;58(1):21-4
8. Brinker SP. Provisional Excellence with Zinc-Oxide Non-Eugenol Temporary Cement. Provider. 2014;501:355110.
9. Nima G, Ferreira PV, Paula AB, Consani S, Giannini M. Effect of metal primers

on bond strength of a composite resin to nickel-chrome metal alloy. Brazilian Dental Journal. 2017 Apr;28(2):210-5.
10. De Angelis F, Minnoni A, Vitalone LM, Carluccio F, Vadini M, Paolantonio M, D'Arcangelo C. Bond strength evaluation of three self-adhesive luting systems used for cementing composite and porcelain. Operative dentistry. 2011 Nov;36(6):626-34.
11. Sunico-Segarra M, Segarra A. Clinical Procedures. InA Practical Clinical Guide to Resin Cements 2015 (pp. 39-76). Springer, Berlin, Heidelberg.
12. Mahasti S, Sattari M, Romoozi E, Baghban AA. Cytotoxicity comparison of Harvard zinc phosphate cement versus Panavia F2 and Rely X Plus resin cements on rat L929-fibroblasts. Cell Journal (Yakhteh). 2011;13(3):163.
13. Shillingburg, Hobo S et al: Fundamentals of Fixed Prosthodontics, 3rd Edn.
14. Rosenstiel SF, Land MF, Crispin BJ. Dental luting agents: a review of the current literature. The Journal of prosthetic dentistry. 1998 Sep 1;80(3):280-301.