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Luting Agents used in Prosthodontics

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Prasad Kulkarni[1], **S. Raghavendra Jayesh**[2]

[1]Post- Graduate student Department of Prosthodontics and Crown and Bridge, Sree Balaji Dental College and Hospital, Bharath Institute of Higher Education and Research, Narayanapuram, Pallikaranai, Chennai - 600 100, India
Corresponding Author E mail: *prasad. k2100[at]gmail.com*
Phone number: 9284362985

[2]Professor & Head of the Department, Department of Prosthodontics and Crown and Bridge, Sree Balaji Dental College and Hospital, Bharath Institute of Higher Education and Research, Narayanapuram, Pallikaranai, Chennai - 600 100, India
E mail: *winkings67[at]gmail.com*

Abstract: ***The choice of an appropriate luting agent is one important factor that affects the long - term clinical success of fixed prosthodontic restorations. There are many different luting agents currently available, ranging from traditional water - based to modern adhesive resin cements, from provisional to definitive luting agents, because no single luting agent can satisfy all the strict requirements. The literature continues to repeat that ''No available product satisfies the requirements for an ideal luting agent and comprehensive patient care requires several materials… the best choice is not always easy''. The purpose of this article is to provide a clinically relevant evaluation of current luting agents in order to improve the dentist's capacity to choose and apply the appropriate cementation technique.***

Keywords: Dental luting agents, provisional and definitive luting cement, zinc phosphate cement, zinc polycarboxylate cement, zinc oxide eugenol cement, glass ionomer cement, resin - modified glass ionomer cement, resin cement.

1. Introduction

The word 'luting' is derived from the latin word lutum which means mud. Dental luting agents serve as a bridge between the prepared tooth and the restoration, bonding them together through some kind of surface attachment that could be chemical, mechanical, micromechanical, or a combination of these. They are used to bond fixed prostheses like crowns, onlays and bridges to the underlying tooth structures. Luting agents are intended to secure the restoration in place and fill the tiny gap between the tooth preparation and implant abutment, preventing it from dislodging during chewing. Depending on their physical properties and the anticipated longevity of the restoration, luting agents can be permanent or temporary.[1, 2]

The choice was simple a century ago because there was essentially just one luting agent, zinc phosphate cement. Currently, numerous luting agents are commercially available. Even for the most experienced clinician, selecting the best luting agent can be challenging. The proper cement selection should be based on knowledge of the physical and biological properties of luting agents.[3]

Properties of ideal luting agents
The cement must satisfy the basic mechanical, biological and handling requirements.

1) It must be well adapted to living dental tissues, have no toxic material that irritates the pulp and ideally, possess anti - cariogenic properties.
2) It should have very low solution ratios in the mouth's liquids.
3) It should have low viscosity and film thickness to reach the tiniest details between the restoration and the tooth.
4) It should be resistant to pulling and mastication forces produced by the effect of gummy foods.
5) It should be sufficiently transparent to light.
6) It must offer enough heat insulation to protect a living tooth from thermal damage.
7) It should give enough working time and be easy to manipulate.
8) It should be able to bond to hard dental tissues,
9) It should have a long shelf life.[4]

Classification of dental cements
In the reviewed literature, there is a considerable variation regarding classification. Various classifications given by different authors are as follows:

1) **Based on the chief ingredients (Craig):**
   a) Zinc phosphate,
   b) Zinc silicophosphate,
   c) Zinc oxide - eugenol,
   d) Zinc polyacrylate,
   e) Glass - ionomer,
   f) Resin

2) **Based on matrix bond type (O'Brien):**
   a) Phosphate,
   b) Phenolate,
   c) Polycarboxylate,
   d) Resin,
   e) Resin - modified glass - ionomer.

3) **Based on knowledge and experience of use (Donovan):**
   a) Conventional (zinc phosphate, polycarboxylate, glass - ionomer)
   b) Contemporary (resin - modified glass - ionomers, resin).

4) **Based on the principal setting reaction (Wilson):**
   a) Acid - base cements
   b) Polymerization cements[5]

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Luting agents

Zinc phosphate cement

It is the oldest luting agent, having been used successfully in clinical practice for more than a century since its introduction in 1878. This cement retains the prosthesis by mechanical means. It is available in powder and liquid system/encapsulated form and it sets through an acid - base reaction. With 2 - 10% of magnesium oxide, zinc oxide makes up the main composition of the powder. liquid is essentially aqueous solution of phosphoric acid (45–64%) buffered by the addition of trace amounts of zinc oxide or aluminium oxide. These compounds combine to form phosphates, which stabilize the acid's pH and reduce its reactivity.[2]

ZnP function is to mechanically interlock at the interfaces to simply adhere prostheses to the tooth. It was renowned for having a strong 103.4 MPa compressive strength, which enables it to withstand pressure from loads that are compressing it. The relative stiffness or rigidity of a material is described by its modulus of elasticity and among the luting agents present, ZnP has the highest modulus of elasticity at 13GPa. Another factor that makes it suitable to be placed in areas with high occlusal forces is its rigidity. When compared to the other luting cements that are available, ZnP exhibits the least creep deformation.[1]

Film thickness is defined as the thickness of the cement coated above the tooth structure. ZnP has an adequate film thickness of less than 25µm. Other benefits of ZnP over resin and GI cement include its low cost, which makes it affordable to use and when excess cement is left behind, it can be easily detected and removed.

However, because ZnP is highly soluble in oral fluids, only a small amount of oral fluid exposure is permissible in the initial setting. ZnP may also irritate the pulp and cause patient discomfort. This is due to the mixture causing an exothermic reaction and the cement needs to be applied to the prepared teeth with a "wet consistency". This indicates that some of the acid has not completely reacted with the powder. The unreacted phosphoric acid which is still present may have instantly dissolved the tooth's smear layer, exposing and penetrating the dentinal tubules and causing sensitivity. Furthermore, patients receiving ZnP treatment may experience post - cementation discomfort due to hypersensitivity. As a result of the tooth's protective function, which involves the deposition of secondary dentine that increases the thickness of the remaining dentine (RDT) and protects the pulp, post - cementation hypersensitivity may resolve on its own. Because the tooth would expect less hypersensitivity, ZnP can be considered for use in situations where the tooth still has a significant amount of RDT remaining. However, root canal therapy is necessary if the irritation persists and the pulp becomes necrotic.[1, 2]

Zinc Oxide Eugenol

Zinc oxide eugenol cement was developed by Dr. J. Foster Flagg in 1875. It is a temporary cement with excellent sealing properties that secure restorations in place. The trade name for zinc - oxide eugenol is Temp - Bond and Fynal (Caulk). Because of its solubility in oral fluids, ZoE is not suitable for luting definitive restorations despite its excellent ability to seal the margins. Additionally, ZoE is radiopaque, which is crucial for detecting any open gingival margins, residual material in prostheses, or the diagnosis of recurrent decay.

A. actinomycetemcomitans, P. gingivalis and F. nucleatum, oral bacteria associated with peri - implant disease were studied by Raval NC. He found that ZoE significantly inhibited the growth of such bacteria., supporting its bactericidal nature. Additionally, a low incidence of peri - implantitis was found in the same study because there was no residual cement. After all, excess ZoE can be easily removed.

Eugenol in ZOE has an obtundent effect on pulp and it exerts an anti - inflammatory effect. Eugenol inhibits the polymerization of resin, so permanent cement treatment, especially one that contains resin, should only be applied after thoroughly cleaning and removing ZOE with an excavator. This material has the highest creep over time even after completely set.

In comparison to the other luting agents, ZOE has the lowest compressive strength value of 2 - 14MPa and the lowest tensile strength value of 0.3 - 2MPa. This explains why it is only suitable as a temporary cement because it cannot withstand excessive stress and would deform under pressure.

The primary concern with eugenol - containing cement is that the phenolic hydrogen - induced residual free eugenol acts as a free radical scavenger and inhibits resin composites from proper polymerization, which has an impact on their microhardness and color stability. When resin - based luting agents are used for permanent cementation, it is advised that non - eugenol formulations be used as provisional luting cement.

Some significant modification includes

1) Addition of cured silicone - based ZOE cement with silane agent (non - eugenol cement)
   It is a temporary cement that is both elastic and firm, insoluble in oral fluids and easily removed by peeling. It is available commercially in an automix syringe kit (Prime - Dent).
2) Eugenol - free cement with calcium hydroxide

It supports the formation of secondary dentin and has bacteriostatic properties. It comes in quick - mix syringes, cartridges and tubes.[1, 2]

Zinc Polycarboxylate

In the 1960s, zinc polycarboxylate (ZnPCB), the first dental cement to chemically adhere to the tooth structure, was introduced. When zinc oxide and magnesium oxide powders are mixed with a viscous solution of high molecular weight polyacrylic acid, an acid - base reaction results, forming ZnPCB. Market names for ZnPCB include Durelon, Hy - Bon and Tylok Plus.

ZnPCB has a good retention capacity, but retention loss with poorly fitting prostheses is to be expected. Additionally, it can chelate, or bond, with the calcium ions in enamel, much

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like GI cement can. Compared to ZnP, which has a tensile strength of only 5 - 7GPa, ZnPCB has 8 - 12GPa. Additionally, ZnPCB has a lower early compressive strength of 55 - 90MPa.

Despite having acid in it, ZnPCB does not cause post - cementation hypersensitivity in patients like zinc phosphate does because the acid used has a high molecular weight, which prevents penetration into the dentinal tubules. Additionally, the rapid pH rise that occurs after mixing makes it biocompatible with dental pulp. It is advised that it be used with metal and metal - ceramic restorations.

In contrast to ZnP, ZnPCB has a lower modulus of elasticity (4–5GPa), which means that it will exhibit greater plastic deformation as a result of pressure after hardening. This makes it unsuitable for use in regions with high occlusal stress.

Furthermore, microleakage is a concern because it may result in tooth sensitivity or even the failure of restoration and few papers state that ZnPCB has the highest microleakage of any dental cement available. While ZnPCB is highly soluble, ideal luting cement requires low solubility to maintain a sealed, intact restoration. It also experiences erosion in acidic environments, indicating that for patients who frequently drink acidic beverages, it is unsuitable. Tarica and colleagues found that ZnPCB is mostly used for long - term temporary cementation of restoration.

Glass Ionomer

In dentistry, glass ionomer cement serves a variety of purposes. It can be divided into three categories: luting cement, restorative cement and lining or base cement. GI is a mixture of an acid - soluble aluminosilicate glass in powder form and an aqueous solution of polymeric acid such as polyalkenoic acid. GI is referred to as glass polyalkenoate cement.

It firmly adheres to the tooth's enamel and, to some extent, to the dentine by a chemical bond formed by ionic interaction between the carboxyl group of polyalkenoic acid and calcium in hydroxyapatite. Among the luting cements, GI cement has the highest compressive strength, ranging from 90 to 220 MPa, but a lower elastic modulus, 8 to 11GPa, than ZnP (13GPa).

Glass ionomer became popular because of its few clinical advantages. In addition to actually bonding to the tooth, the short setting time has the advantage of requiring less time during treatment. Furthermore, fluoride content in glass ionomer cement is an added advantage. Its fluoride release ability under acidic conditions is one of the major advantages. GICs have low film thickness. GIs are considered to set fast i. e. within two to three minutes after mixing. GIs are water resistant. Water has a few essential roles in GI cement: first, it facilitates proton release from the polymer, which allows it to act as a solvent for polymer to act as an acid; second, it serves as a medium for the setting reaction to occur; and third, it is one of the components of the set cement. The addition of water to GI cement increases its translucency, which is crucial for aesthetic purposes.

Since it has a lower modulus of elasticity, there is a likelihood that it will deform over time. The GI is sensitive to both water uptake and loss during the setting process. GI cement exhibits high microleakage if there is inadequate moisture control and microcracks may occur instead if it is dried excessively. Cement loses strength, resistance and aesthetics when it is over - or under - hydrated. Therefore, it is essential to maintain the water balance within the GI cement matrix. GIC may develop microcracks that have a chalky appearance when unbound water is lost from it. In areas with heavy occlusal forces, GI is not advised for use.

Resin Modified Glass Ionomer

Polymerized resins and conventional glass ionomer components are combined to form the hybrid material known as resin - modified glass ionomer (RMGI). RelyX Luting, RelyX Luting Plus (3 M/ESPE), Fuji Plus (GC), and UltraCem RRGI Luting Cement are a few examples of RMGI cement used commercially. With an additional monomer component and associated initiator system, in RMGI the same fundamental components are found as glass ionomers. Typically, 2 - hydroxyethyl methacrylate (HEMA) is used as the monomer and camphorquinone is the initiator in RMGI.

The physical characteristics of RMGIs are similar to those of the conventional GI. They can both release fluoride in acidic environment. Similar to conventional GI, RMGI releases trace amounts of sodium, aluminum, phosphate and silicate under neutral conditions. Under acidic conditions, these are then released in higher concentrations, which corresponds to a buffering effect. In contrast to GI cement, RMGI is less soluble and more resistant to early erosion in an acidic environment.

Compressive strength of RMGI ranges from 85 to 126 MPa. The tensile strength rises to 13–24GPa as a result of the additional resins. It is more convenient for dentists as it is easier to manipulate RMGI cement than GI cement. However, polymerization shrinkage is shown in RMGI cement. This leads to internal and marginal discrepancies and a decrease in cement strength.

RMGI has an advantage over conventional GI cement because it is less likely to get contaminated with moisture and less likely to desiccate while setting. This is due to presence of the covalent crosslinking of the polyacrylate salt from free radical polymerization.

Due to the hydrophilic nature of HEMA, RMGI exhibits the highest water sorption of all luting cement currently available. Water sorption will impact the resin's mechanical properties, but the resulting expansion could be helpful because it will counteract polymerization shrinkage. The biocompatibility of RMGI is significantly lower than that of GI. This is because these compounds release HEMA, which has some harmful biological properties. The degree to which the cement is light - cured affects how much HEMA is released. HEMA is cytotoxic to pulp cells as it can diffuse through the dentine.

Dental professionals should use this cement with caution because it may have the risk of experiencing adverse effects

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like contact dermatitis and other immunological responses.2 - HEMA is known to cause delayed hypersensitivity reactions when tested in guinea pigs, which is supported by Katsuno, K. et al. Both patients and dental professionals may experience allergic responses as a result of the release of HEMA. HEMA is a volatile substance that can trigger allergic reactions upon direct contact. To help avoid inhaling the vapour, clinicians should use RMGI in a well - ventilated area.

RMGI is an excellent cement for those who are concerned about aesthetics because it is available in a variety of shades. In addition, RMGI is cement of choice in the areas where high occlusal forces are anticipated because it has high physical strength.

Resin

In the middle of the 1980s, polymer matrix composed of bis - GMA or urethane dimethacrylate and filler of fine inorganic materials was first used to fill and seal tooth restoration gaps. To prepare enamel, dentin, alloy and ceramic surfaces, resin bonds micromechanically. These resins can be divided into different categories based on their polymerization mechanisms i. e. resin can be activated by chemical cure, a light cure, or a dual - cure method.

The photo - initiator found in light - cure resin cement, as its name suggests, can be activated by light. They are useful when the cementing restoration is thin, allowing light to pass through to the resin cement. Light cure cement enables the clinician to remove extra cement before cure. This is a benefit because removing hardened excess cement is very difficult. Light curing of entire luting cement, on the other hand, is a major concern. This is because incomplete polymerization will cause unreacted monomers to irritate the pulp.

Chemical cure resin cement also known as self - cure cement, is particularly helpful in areas where light cure is not feasible because it polymerizes through a chemical reaction. Two materials are mixed to start the polymerization reaction. In contrast to light - cured cement, chemically polymerized resin doesn't have a wide range of shades and translucency options and its color stability may not be as satisfactory as compared to light - cured cement. Examples include Panavia (Kuraray Dental).

A combination of chemical and light curing methods are used to cure dual - cure resin cement. Due to the accessible areas' benefit from light polymerization and their greater color stability, dual cure resin cement can be advantageous. Chemical curing is used in places where light curing is not feasible. Dual - polymerized resin cement is recommended when the restoration is too thick to enable complete light transmission. NX3 Nexus Third Generation (Kerr) is a type of dual - cure resin cement.

Resin has high tensile strength and high compressive strength, making it ideal for use in the posterior region i. e.70 - 172 MPa. The size of the abutment is another problem with the use of luting cement. In a 2018 study, Safari, S. et al. discovered that single crown restorations on short abutments had more retention problems. For short abutments, resin cement may be suggested due to its high retentive strength.

In oral fluids, resin cement is highly insoluble. To compete with GIC, newer resin cement is said to contain fluoride for anti - cariogenic purposes, but the material's effectiveness is still under evaluation and needs more research to prove. As was previously mentioned, polymerization shrinkage occurs in resin cement and causes unnecessary marginal leakage.

Clinicians who use resin as luting agents must be skilled enough to handle and complete treatment within the setting time because excess resin cement is difficult to remove after setting.1

2. Conclusion

As a result of the consideration and evaluation of the characteristics, benefits and drawbacks of various luting agents in this paper, it can be said that no luting agent is currently available that is ideal for all clinical situations in prosthodontics. The selection of proper luting agents for usage depends on various factors including the type of restoration used, requirements of the patients as well and the experience of the dentists themselves.

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