Review Article

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An Insight Into the Bioactive Luting Cement.

Abstract:
A large number of luting agents (dental cements) are available and proper selection can be a daunting task and is usually based on a practitioner's reliance, on their experience and preference. 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". Ceramic restoration in the form of indirect crowns and fixed partial dentures form the mainstay of oral rehabilitations. However, their use has made luting procedures more challenging. The aim of cementation is to integrate the restorations with the dental hard tissues, especially with the dentin, supplying retention, marginal sealing, and esthetics. Zirconia FPDs can be luted with conventional cements (zinc phosphate cement and glass ionomer) but they show high solubility and low mechanical resistance in the presence of bioactivity and fluoride release. Commonly used resin luting agents are sensitive to moisture, undergo dimensional changes (polymerization and thermal), show minimum bacterial resistance, and lack dentin remineralization potential, fail to create a natural chemical bond to dentin and lack bioactivity to prevent microleakage. It is proposed that contemporary bioactive esthetic materials have the potential to reduce bacterial microleakage and enhance marginal integrity by showing recharge and renewal of restorative material constituents.The purpose of this article is to review variousluting agents, their properties & associated clinical implications and to help the clinician to select an appropriate luting agent for a given clinical situation.

Key-words: Luting cements, Bioactive luting cements, Indirect restoration, Zirconia crowns, Microleakage

Introduction:

An indirect restoration must be cemented with a 'luting agent', which is basically the last stage of consecutive clinical procedures determines the long-term success of the FDP's.A dental cement used to attach indirect restorations to prepared teeth is called a luting agent. [4]The success of the fixed prosthodontic restoration is affected by a variety of factors (clinical and laboratory) some of them are the form of tooth preparation, oralhygiene, mechanical forces and restorative materials. However, the choice of a proper luting agent is the key factor to success. Loss of crown retention was found to be the second leading cause of failure of crowns and fixed partial dentures.[3]Although the establishment of optimal resistance and retention forms in the tooth preparation are of prime importance, a dental cement must be used to act as a barrier against microbial leakage, sealing the interface between the tooth and restoration and holding them together through some form of surface attachment. This attachment may be mechanical, chemical, or a combination of both methods.[2]Currently a wide range of luting agents are available in the market which makes the selection of an optimal luting cement critical for the clinician. Historically the progression of luting agents includes in succession, zinc phosphate, polycarboxylate, glass ionomer, resin, and resin modified glass ionomer cements.

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These cements are now followed by recently introduced bioactive esthetic materials in the market for restoration and cementation of indirect restoration, which associate with oral fluids and have the potential to reduce bacterial microleakage and enhance marginal integrity by showing continuous recharge and renewal of restorative material. [15]

These materials have evolved from clinical indications in which their initial low strength properties were adequate, such as root replacement materials and direct pulp capping materials, to more physically demanding indications, such as luting agents, liners, bases, and temporary restorative materials.[14] Theability of the bioactive cement to predictably seal and reseal its marginal interface with the abutment could be a significant advancement in the field of dentistry and potentially lead to a new class of dental restorative materials.

Idealproperties of a Luting agent

Biological properties:

An ideal dental luting agent should be biocompatible, have little interaction with body tissues and fluids, be nontoxic, and non-allergic,actively prevent caries at the restoration-tooth interface and Resistant to microleakage.

Mechanical properties:

The luting agent must have sufficient strength to resist fracture and also longer-term cyclical fatigue stresses. It should have Low solubility, Water sorption, setting stresses and should be resistant to Wear

Esthetic properties:

With the increasing use of translucent ceramic restorations, especially for anterior restorations,esthetic properties are of considerable significance. The luting agent should have color stability, radiopaque to enable the clinician to distinguish between a cement line and recurrent caries, as well as to detect cement overhanging's.

Working properties:

Luting agent should have adequate film thickness and viscosity to ensure complete seating, easy to manipulate, demonstrate adequate working and setting times. [2,7,6.]

Classification:

Luting agents can be classified into permanent or provisional depending on their physical properties and planned longevity of the restoration. [3,5,7,8]According to adhesive potential, they can be divided into low (zinc phosphate, silicate cements), medium (polycarboxylate cement), or high (glass ionomer cements and filled or unfilled resins) luting materials.7. From the chemical point of view, cements are classified in two groups, namely water-based cements basically including zinc phosphate and glass ionomer cements (GIC) and resin-based or polymerizing cements consisting of resin modified glass ionomers (RMGI) and conventional composite and self-adhesive cements.[1,3]They can be classified into conventional and contemporary cements.3. Craig classified cements according to chief ingredients (i.e., zinc phosphate, zinc silicophosphate, zinc oxide-eugenol, zinc polyacrylate, glass-ionomer, and resin)[19] O'Brien classified dental cements by matrix bond type (i.e., phosphate, phenolate, polycarboxylate, resin, and resin-modified glass-ionomer)[20]. Whereas, Donovan classified the cements into conventional (zinc phosphate, polycarboxylate, glassionomer) and contemporary (resin-modified glass-ionomers, resin) based on knowledge and experience using these materials [21]

Zinc phosphate:

Due to its long clinical history, zinc phosphate cement serves as the 'reference' or 'gold standard to which other definitive luting agents are compared. [1,8]Zinc phosphate sets by an acid-base reaction. Compressive strength of zinc phosphate is relatively high (80 to 110 MPa), is not expensive per unit dose 4, it is a good choice for luting long span fixed partial dentures or cantilevered prostheses due to its high modulus of elasticity (13 GPa).[1,2,8]However, Microleakage aggravated by degradation in oral fluids and an initial low setting pH, may affect its biocompatibility in clinical use. [2] It does not bond to the tooth structure providing only a mechanical retentive seal. Therefore, the length, taper and surface area of the tooth preparation are important for its success. The cement has high solubility in oral fluids and has low tensile strengths (5 to 7 MPa). Post cementation discomfort is a known unfavorable side effect when using this cement. [5]

Zinc Polycarboxylate Cement:

Thiscement was developed by Dr. Dennis Smith, a Manchester dentist in 1968 and phosphoric acid was replaced with a new polymeric acid, polyacrylic acid and it was the first chemically adhesive cement. [3] The cement sets by an acid–base reaction. The adhesive bond is primarily to enamel although a weaker bond to dentin also forms as a result of chelation reaction between the carboxyl groups of the cement and calcium in the tooth structure; hence, the more mineralized the tooth structure, the stronger the bond. This cement is hydrophilic so is capable of wetting dentinal surfaces. It has a property of pseudoplasticity and shows shear-thinning behaviour. Therefore, though the mixed cement appears too thick, it flows adequately under pressure to a film thickness of 25–35 micro m.[3] Ascompared to zinc phosphate cement, its early compressive strength is lower but the tensile strength is much higher.[8]It is the material of choice for vital or sensitive teeth with preparations close to the pulp due to its rapid rise in pH after mixing, being weaker than phosphoric acid and Lack of tubular penetration from large and poorly dissociated polyacrylic acid molecules. It is not resistant to acid dissolution so it should be avoided in patients who have gastric reflux problems or frequently consume acidic beverages.[8] Deforms under loading so it is not well-suited for use in regions of high masticatory stresses and for long span prostheses. So, the use of this cement is limited for the cementation of single metal units in low stress areas on sensitive, vital teeth. [2]

Glass-Ionomer Cements (Glass-Polyalkenoate Cements) :

Developed by Wilson and Kent in 1969, at the Laboratory of the Government Chemist in England, 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.[3]The International Standards Organization officially uses the name "glass polyalkenoate cement," with the term "glass-ionomer" considered as generic, and covering a larger group of cements with similar compositions.[4] It adheres to tooth structure by formation of ionic bonds at the tooth - cement interface as a result of chelation of the carboxyl groups in the acid with the calcium and/or phosphate ions in the apatite of enamel and dentin. This cement has the advantages of both silicate cement (translucency and fluoride release) and polycarboxylate cement (kindness to pulp and chemical adhesion to tooth structure)3 The compressive strength is higher (90 to 230 MPa) than the zinc phosphate cement.[2]However, their modulus of elasticity is lower than zinc phosphate cements; thus, there is potential for elastic deformation in areas of high masticatory stress.[2]The main drawbacks of this cement are its susceptibility to moisture attack and subsequent solubility if exposed to water during the initial setting period and their susceptibility to dehydration, leading to cohesive failure from microcrack formation.With the use of GIC as a luting agent, frequent post cementation sensitivity has been reporteddue to its initial low setting pH. [3,5]

Resin-Modified Glass-Ionomer Cements:

Introduced in 1990s with an objective to combine fluoride release and chemical adhesion property of glass-ionomer cements with high strength and low solubility of resins.3.RMGI cements are hybrid, dual-phase materials with similar manipulative properties to GICs but they set faster and are stronger.[1] Are considered to be 'dual polymerized and hybrid materials as these cements sets by an acid-base reaction and by photo-initiated or chemically initiated free radical polymerization of methacrylate units. [2]RMGIC cements have some advantages over conventional GICs, such as longer working time, controlled setting on application of the relevant light source, aesthetics closer to resin-based materials and the tooth, better strength characteristics, improved bond strength, reduced superficial degradation and increased wear resistance. However, RMGI cements suffered from certain drawbacks such as setting shrinkage, limited depth of cure especially with more opaque lining cements, dimensional change owing to water uptake of the resin phase and surface porosity.[1] Resin ionomer cements present concerns regarding biocompatibility due to the presence of free monomer in the liquid. [2] HEMA is responsible for increased water sorption, subsequent plasticity and hygroscopic expansion. Initial water sorption may compensate for the polymerization shrinkage stresses, but continual water sorption leads to substantial dimensional change, contraindicating their use for the cementation of all-ceramic crowns and posts in non-vital teeth as expansion induced fracture occurs.[3]

Self-adhesive resin composite cements:

The poor adhesive properties of the RMGIs have led tothe introduction of adhesive resin cements.Self-adhesive resin cements eliminate the need for separate etchants and primers for bonding to tooth, alloy, or ceramic substrates to maximize their performance and are the newest among resin cements.[5,11,9]However they show lower bond strength when compared to the self-etch and total etch cements.[11]The main components of SARCs are as follows: 1) aromatic and aliphatic dimethacrylate monomers to form a cross-linked network, 2) acidic methacrylate monomers to adhere with enamel and dentin and copolymerize with the cross-linking monomers,3) glass filler particles or basic compounds to neutralize residual acidic monomers, 4) conventional silanated filler particles to provide strength by an inert reinforcing effect, 5) appropriate catalysts and stabilizers to comply with the dual-cure characteristic and shelf-life requirements, and 6) pigments and opacifiers to fulfill the esthetic requirements.Luting [5]. polymerization of Self-adhesive cements can be either in self-cure mode or in dual cure mode. The degree of conversion was found to be much higher in dual cure mode, yet remained less than conventional resin cements. The bonding efficacy of self-adhesive cements especially in deep dentin was found to be more challenging for self-adhesive cements owing to reduced area of solid intertubular dentin associated with the increased water content, compared to superficial dentin. [1] They can be used when retention is less, in short crowns, onlays with less number of walls. They are the cements of choice for high strength ceramics like alumina and zirconia but they lack bioactivity. Only contraindication of self-adhesive cements is not to be used for cementation of laminate veneers.[11]

Bioactive luting cements:

Conventional acid–base cements (zinc phosphate and glass ionomer cement (GIC)) show high solubility and low mechanical resistance in the presence of bioactivity and fluoride release. So, the use of acid–base cements is discouraged for ceramic cementations. Commonly used resin luting agents have various advantages like excellent translucency, controlled setting, low cement film thickness, resistance to post-polymerization solubility, and mechanical strength, However, they demonstrate sensitivity to moisture, undergo dimensional changes (polymerization and thermal), show minimum bacterial resistance, lack dentin remineralization potential, fail to create a natural chemical bond to dentin and lack bioactivity to prevent microleakage.Therefore, bioactive materials have been introduced for restorative and luting purpose of indirect ceramic restorations.[18] These materials have evolved from clinical indications in which their initial low strength properties were adequate, such as root replacement materials and direct pulp capping materials, to more physically demanding indications, such as luting agents, liners, bases, and temporary restorative materials. Besides luting agents' other bioactive materials are Mineral Trioxide Aggregate, Bioaggregate, Biodentine, Endosequence, Bioactive Root Canal Sealers Root Repair Material.[17] In 1969, Hench gave the concept of bioactivity as “A bioactive material is one that elicits a specific biological response at the interface of the material which results in the formation of a bond between the tissues and the material”. [17] The material demonstrate bioactivity by exchange of ions, based on oral pH, between oral fluid and the ionic resin matrix. They associate with oral fluids and show continuous recharge and renewal of restorative material constituents, have the potential to reduce bacterial microleakage and enhance marginal integrity when used as luting agent. The bioactive materials are based on silica glass particles and an ionic-based resin matrix with calcium, phosphate, and fluoride ions.

Composition of the bioactive cement - Paste A: Diurethane dimethacrylate and other methacrylate-based monomers and oligomers, polyacrylic acid/maleic acid copolymer, water, barium borosilicate glass, silica, reducing agents, photo initiators and colorants. Paste B: Diurethane dimethacrylate and other methacrylate-based monomers and oligomers, aluminoflurosilicate ionomer glass, silica and oxidizing agents. In the presence of water, ionization causes the replacement of hydroxyl groups in phosphate acid of the matrix with the calcium in dentin, resulting in a chemical bond. This ionic exchange results in binding of the bioactive luting agent to the tooth structure, forming a hydroxyapatite complex resulting in marginal seal.[22]Besides, the absence of bonding agent application for bioactive cement allows the prevention of fluid percolation in and out of the hybridized complex of dentin and bioactive cement. Moreover, bioactive cements are claimed to extract fluoride, calcium, and phosphate ions from the environment, based on the changing pH. This allows for reactivation of the cement and dentin, resulting in a durable chemical bond and seal at the dentin cement complex.

The manufacturer claims that bioactivity facilitates the benefits of improved durability, antimicrobial resistance, the chemical bond with dentin, and minimizes leakage due to oral contaminants. This group of cements demonstrate three characteristics (1) they contain comparably high levels of calcium, (2) they display a pH in the alkaline range, and (3) they are bioactive, means these materials form surface apatite in the presence of physiological levels of inorganic phosphate in a simulated body fluid (SBF).[14] In a study on microleakage assessment of bioactive restorative materials using methylene blue dye and class V cavities by Owens et al revealed no difference in microleakage for bioactive and resin restorative materials.As bonded ceramic crowns and veneers enhance their fracture resistance through adhesive bonding to tooth, ability of bioactive cements to provide mechanical support to dentin bonded crowns and veneers is critical for clinical restorative success.[23]

In a study by Girn et al., compressive and tensile strengths of bioactive materials were shown to be comparable to resin materials. [16]In a study onrestorative marginal integrity of ceramic crowns luted with bioactive and resin cements using micro-computed tomography (micro-CT) microleakage evaluations and bond strength assessment by Fahim Vohra et al revealed that Mean SBS among bioactive (21.54 ± 3.834 MPa) specimens was significantly higher than that for GIC (14.08 ± 3.25 MPa) specimens ($p < 0.01$), but they were comparable to resin samples ($p > 0.05$) (24.73 ± 4.32 MPa). Microleakage was significantly lower in crowns luted with bioactive (0.381 ± 0.134) cement compared to GIC (1.057 ± 0.399 mm3) ($p < 0.01$) and resin (0.734 ± 0.166 mm3) ($p = 0.014$) cemented crowns.[18] The type of luting agent had a significant influence on the microleakage of crowns and bond strength to dentin ($p < 0.05$). Steven R. Jefferies in his study concluded that the surface apatite-forming, calcium-based, bioactive dental cements have the capability to seal or reseal artificial marginal gaps in simulated aqueousphysiological conditions.[14]

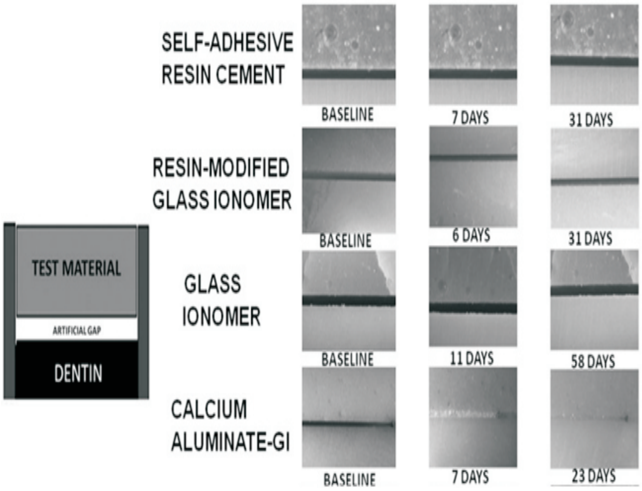

FIG 1:Illustration of progressive closure of artificial marginal gaps created between various luting cements and dentin

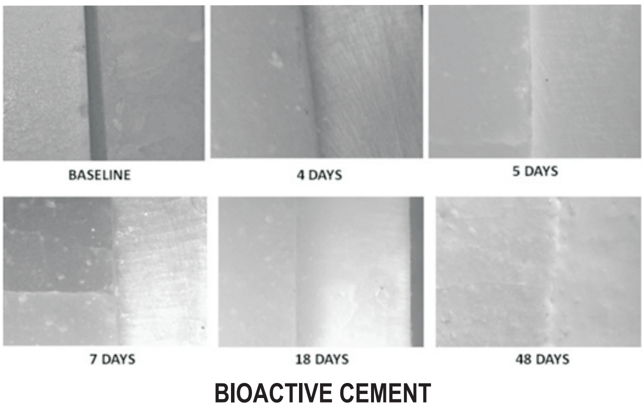

FIG 2: Illustration of progressive closure of artificial marginal gaps created between a bioactive cement and dentin

The ability of this material to predictably seal and reseal its marginal interface with tooth structure could be a significant evolution in dental restoratives and possibly lead to a new class of dental restorative materials with greater safety and efficacy against secondary caries, and prevention of bacterial access to dentinal tubules and the pulp itself.

Discussion:

Since there is no ideal luting agent available for all cementation purposes and the above-mentioned properties of a cement are also associated with several confounding clinical factors (i.e., occlusion, preparation design, moisture control, type of build-up material, type of supporting tooth structure, surface roughness, margin location, tooth location, amount of tooth destruction and abutment mobility) that determine the selection of the cement. One of the determinants of the choice between water-based or polymerizing cements is concern about microleakage and eventually secondary caries on the dental tissues underneath the FDP.

The solubility and disintegration behaviour of luting cements that relate to the long-term loss of seal between the abutment and the prosthesis are important factors that determine the clinical longevity of FDPs and posts. When compared with GIC, RMGI and resin cements, zinc phosphate cement, under in vivo conditions has been demonstrated to disintegrate the most[1].An in vivo study [7] with patients wearing luting specimens in the lingual flanges of inferior complete dentures showed that polycarboxylate and zinc phosphate cement dissolved more than glass-ionomer cement. Under scanning electron microscopy, glass-ionomer and polycarboxylate cements showed pits and extensive cracks on their surfaces, while zinc phosphate showed a large number of pits. In general, it is accepted that resin luting cements are less soluble than other luting material.

In terms of temperature effects on pulp, zinc phosphate cement exhibits the highest temperature rise during setting reaction especially with an increasing powder or liquid ratio (10.92–13.80°C), whereas GIC exhibits the lowest rise (1.82–2.75°C). [3]

When using a traditional non adhesive luting agent such as zinc phosphate, retention is dependent on the geometric form of the tooth preparation that limit the paths of displacement of the cast restoration. In practice, ideal axial wall convergence is rarely obtained, and lack of retention is a common cause of fixed prosthesis failure.

In an in vitro study by Sidhant Pathak et al it was concluded that the retentive strength of dual-polymerized self-adhesive resin cements was better than RMGIC.[12]In a study by Yucel et al it was concluded that 1. Resin cement significantly improved crown retention when compared against RMGIC. However, the difference was not significant when compared against GIC. 2. The higher the retentive force a crown possessed, the lower the possibility of microleakage. 4. In SEM micrographs, there was intimate adaptation between resin cement and tooth structure and between resin cement and SSC.It has been suggested that resin luting cements have higher mechanical properties than both GICs and RMGICs [13]

In a study by Steven R. Jefferies capability of different luting cements (self-adhesive resin cements, resin modified GIC, Glass ionomer cement and Bioactive cement) to seal or reseal artificial marginal gaps in simulated aqueous physiological conditions were tested and he concluded that calcium-based, bioactive dental cements have the ability to form surface apatite-crystals and to seal or reseal artificial marginal gaps in simulated aqueous physiological conditions.[14]The results of this laboratory study, although preliminary in nature, suggested a new functional property for bioactive dental materials, namely the ability to significantly improve marginal stability with tooth/restorative material interface. Such behavior in a restorative material could improve the survival and serviceability of dental restorations.[14]

Conclusion:

Although no available product satisfies all the requirements of an ideal luting agent, the outstanding clinical performance of conventionally fabricated indirect restorations should be appreciated before the practitioner is willing to abandon traditional materials for the latest formulation. Nevertheless, the advent of adhesive techniques has allowed the modern dentist to expand services, and many procedures cannot be provided with traditional water-based luting agents. In practice, several materials are needed to provide comprehensive patient care. Although some materials are contraindicated for certain techniques, the best choice is not always clear.The ability to seal or reseal marginal gaps or defects could provide a new and unique aspect to the survival and serviceability of dental restorations and opens a new perspective on the clinical significance of bioactivity in dental restorative materials. It is possible that this newly recognized, preliminary finding concerning the capacity of “bioactive” materials to seal or reseal marginal gaps could bring us to a better understanding of this class of materials as well as the clinical significance of bioactivity as a fundamental property of these materials and could potentially add a new useful additional protective function to tooth-colored restorations in restorative dentistry.

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