RESEARCH ARTICLE

CURRENT UPDATES ON LUTING AGENTS: A REVIEW WITH RECENT TRENDS

ABSTRACT

The selection of an appropriate luting agent is mandatory for the long term clinical success of fixed prosthodontic restorations. Not all luting agents can meet all the stringent requirements, that is why there is such a wide choice of luting agents currently available from conventional water-based to contemporary adhesive resin cements. Introduction of adhesive resin systems has completely changed the face of fixed prosthodontic practice leading to an increased use of bonded all-ceramic crowns and resin-retained fixed partial dentures. This article tries to review recent updates and advancements on luting cements

Key words: Dental luting cements, Glass Ionomer Cement, luting cements, provisional and definitive luting cements, resin cements, resin modified luting cements, nanotechnology, adhesive dentistry, restorative dentistry, advantages and disadvantages, ideal requirements, recent advances.

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INTRODUCTION

Dental cements are used as luting agents and restorative materials in the oral cavity. The most obvious use of dental cements is for permanently retaining metallic and non-metallic inlays, crowns, and bridges to tooth structure. Cements used in this manner are called Luting agents because they lute, or adhere, one surface to another. Dental cements can also be used as protecting materials after the cavity preparation to protect the pulp against further trauma, like thermal and chemical insulating bases under metallic restorations and others like composites restorations and pulp-capping agent and cavity liners. Multiple factors affect the success of fixed prosthodontic restorations with preparation design, oral hygiene/microflora, mechanical forces, and restorative materials being some of them. However, key factor to success is the choice of a proper luting agent and the cementation procedure. Loss of crown retention was found to be the second leading cause of failure of crowns and fixed partial dentures[1] while a study listed uncemented restorations as the third leading cause of prosthetic replacement with failure occurring after only 5.8 years of service[2]. This article reviews numerous luting cements, their composition, chemistry, properties with their advantages and disadvantages and advancements from the literature.

LUTING CEMENTS

Luting agents are used like glue to retain the metallic, ceramic and composite crowns, bridges inlays and onlays permanently. In dentistry, use of dental cements as a luting agent is employed for two major purposes such as to secure cast restoration in fixed prosthodontics and to retain orthodontic bands and appliances in position, and to serve as a restorative material either alone or with other materials[3]. Uses of luting cements for fixed prosthodontic purposes, require preparation of the tooth surface (i.e. 1.5 to 2 mm of enamel and dentin must be removed to create space in which the cement is placed). So the most important aims of the luting cements in fixed prosthodontics are to prevent the bacteria and oral fluids from penetration into the prepared surface and insulate the thermal conduction as well as retention of the restoration by filling the gap between the tooth surface and the restoration[4]. While in orthodontics, the preparation of tooth surface is eliminated (no need to remove any enamel or dentin) where the cements are placed directly on the teeth. However the most important aim of luting cements is to retain the bands in position without detachment. Various luting cements used for luting of fixed restorations and orthodontic appliances as well are zinc phosphate cements, zinc polycarboxylate cements, glass ionomer cements, hybrid ionomer cements, resin modified glass ionomer cements, polyacid modified resin cements, and resin cement .

1. IDEAL REQUIREMENTS OF LUTING AGENTS [1,2,5-10]

- Should provide a durable bond between dissimilar materials.
- Should possess favourable compressive and tensile strengths.
- Should have sufficient fracture toughness to prevent dislodgement as a result of interfacial or cohesive failures.
- Should be able to wet the tooth and the restoration.
- Should exhibit adequate film thickness and viscosity to ensure complete sealing.
- Should be resistant to disintegration in the oral cavity.
- Should be tissue compatible.
- Should demonstrate adequate working and setting times.

PROPERTIES	IDEAL REQUIREMENTS
Biological	• Non-toxic and non-irritant. • Non-carcinogenic. • Should not cause any systemic reactions. • Should be cariostatic thus preventing secondary caries formation.
Chemical	• Should be chemically inert. • Should bond chemically to the enamel and dentin. • PH should be neutral.
Rheological	• Low film thickness to enable the easy flow of luting cement. • Longer mixing and working time. • Shorter setting time.
Mechanical	• High compressive strength to withstand the masticatory forces. • High tensile strength to reduce the brittleness. • High modulus of elasticity. • Should bond chemically to the enamel and dentin.
Aesthetic	• Should not alter the color of the tooth and artificial restorations/prosthesis. • Should have adequate radiopacity to enable detection of secondary caries.
Thermal	• Good thermal insulator. • Coefficient of thermal expansion (COTE) should be similar to the tooth and artificial prosthesis.

2. INDICATIONS AND CONTRAINDICATIONS FOR LUTING AGENT[11,12]

TYPE OF PROSTHESIS	ZINC PHOSPHATE	ZINC POLY-CARBOXYLATE	RMGIC	GLASS IONOMER	RESIN CEMENT
PFM crown.	Indicated	Indicated	Indicated	Indicated	Indicated
Pressed ceramic crown, ceramic inlay, ceramic veneer, resin bonded FPD	Contra-indicated	Contra-indicated	Contra-indicated	Contra-indicated	Indicated
Patient with history of post-treatment sensitivity		Indicated			Contra-indicated
Crown or FPD with poor retention	Contra-indicated	Contra-indicated	Contra-indicated	Contra-indicated	Indicated
Cast post and core	Indicated	Contra-indicated	Indicated	Indicated	Indicated

3. PROPERTIES OF LUTING AGENTS

The selection of a luting agent for luting of various prostheses is mainly based on their properties. Most important properties of luting agents include biological, rheological, physical, and mechanical properties. Luting agent has different physical, mechanical and biological characteristics resulting from its chemical structure[2-4,11-33].

Luting agent	Biological (Effect on Pulp)	Chemical			Rheological			Physical & Mechanical		
		pH		Solubility in water at 24 hrs.	WT (min)	ST (min)	FT (µm)	CS (MPa)	TS (MPa)	MOE (GPa)
		2 min	24 hrs.							
Zinc Phopsphate	Severe Irritant	2.14	6	0.2%	3 – 6	5 - 14	25	103.4	5-7	13
Zinc Polycarboxylate	Mild effect	3.42	7	0.06%	2.5 – 3.5	6-9	25-30	55-90	8-12	4-5
Glass Ionomer	Mild effect	2.33	5.68	0.4-1.5%	2-4	6-9	25	90-220	6-7	8-11
RMGIC	Mild effect	3-5		0.07-0.4%	2-4	5-6	25	85-126	13-24	4 2.5-7.8
Methacrylte resin cements	Moderate effect			0.0-0.01%		2-4	< 25	70-172		2.1-3.1

WT = Working Time
ST = Setting Time
CS = Compressive Strength
TS = Tensile Strength
MOE = Modulus of Elasticity

4. ADVANTAGES OF LUTING AGENTS[1-5, 21-33]

ZINC PHOSPHATE	ZINC POLY-CARBOXYLATE	GLASS IONOMER	RMGIC	RESIN CEMENT
Reasonable working time	Favourable tensile strength	Adequate resistance to acid dissolution	Improved compressive strength, diametral tensile strength, and flexural strength	Superior compressive and tensile strengths.
Adequate film thickness (25 µm).	Chemical bonding	Anticariogenic	Less sensitive to early moisture contamination and desiccation during setting	Available in wide range of shades and translucencies
Can be used in regions of high masticatory stress or long span prosthesis.	Pseudoplastic	Ability to absorb fluoride recharge from the oral environment makes it the cement of choice in patients with high caries rate.	Adequately low film thickness.	Low solubility
Good compressive strength	Biocompatibility with the dental pulp	Low film thickness and maintains constant viscosity for a short time after mixing	Fluoride release similar to conventional GIC.	
	Adequate resistance to water dissolution	Chemical bonding	Minimal post-operative sensitivity	

ZINC PHOSPHATE	ZINC POLY-CARBOXYLATE	GLASS IONOMER	RMGIC	RESIN CEMENT
Highly acidic.	No resistance to acid dissolution	Initial slow setting	Polymerization shrinkage	High film thickness
Low tensile strength	Manipulation critical	Sensitivity to early moisture contamination	Although rare, may elicit an allergic response due to free monomer	Marginal leakage due to polymerization shrinkage
No chemical bonding	Early rapid rise in film thickness that may interfere with proper seating of a casting	MOE is lower than zinc phosphate	Cement bulk is very hard and difficult to remove	Lack of anticariogenic properties
Solubility in oral fluids		Post ceme-ntation sensitivity		No Chemical bonding
Lack of antibacterial properties.				

RECENT ADVANCEMENTS IN GLASS IONOMER MATERIALS

Different advances in glass ionomer such as compomers, condensable/ self-hardening GIC, low viscosity/ flowable GIC, fiber-reinforced GIC, chlorhexidine-impregnated GIC, proline-containing GIC, nano-bioceramic-modified GIC, and calcium aluminate GIC have been introduced in dentistry.

1. COMPOMER: It is a combination of the word “comp” for composite and “omer” for ionomer. Though introduced as a type of GIC, it became apparent that in terms of clinical use and performance, it is best considered as a composite.

2. CONDENSABLE/SELF-HARDENING GIC: These are basically, purely chemically activated resin-modified glass ionomer cements (RMGICs) with no light activation at all. It is used mainly in pediatric dentistry for cementation of stainless steel crowns, space maintainers, bands, and brackets.

3. LOW VISCOSITY/FLOWABLE GIC: It is mainly used as lining, pit and fissure sealing, endodontic sealers, sealing of hypersensitive cervical areas, and it has increased flow.

4. BIOACTIVE GLASS: Developed by Hench and colleagues in 1973, this material considers the fact that on acid dissolution of glass, there is formation of a layer rich in calcium and phosphate around the glass, such a glass can form intimate bioactive bonds with bone cells and get fully integrated with the bone. It is used in retrograde filling material, for perforation repair, augmentation of alveolar ridges in edentulous ridges, implant cementation, and infrabony pocket correction.

5. FIBER-REINFORCED GIC: To improve the depth of cure, reduced polymerization shrinkage, improved wear resistance, and increase in flexural strength of GIC, alumina fibers are mixed with glass powder. This technology is called the polymeric rigid inorganic matrix material, which involves incorporation of a continuous network/scaffold of alumina and silicon di oxide ceramic fibers.

6. CALCIUM ALUMINATE GIC: A hybrid product with a composition between that of calcium aluminate and GIC, it is designed for luting fixed prosthesis. The calcium aluminate contributes to a basic pH during curing, reduction in microleakage, excellent biocompatibility, and long-term stability and strength.

INTRODUCTION OF NANOTECHNOLOGY IN GICS

Nanotechnology is introduced in conventional GIC and resin-modified GIC to improve the mechanical properties of GIC. It has been concluded that large number of modifications were carried out with GIC, and the introduction of nanotechnology had improved the general properties of GIC. Nano-resin-modified GICs (nano-RMGICs) do not possess any substantial advantage or disadvantage, in terms of surface mechanical properties, compared to conventional restorative materials.

Nanotechnology involves the use of systems, modifications, or materials that have the size in the range of 1-100nm[34-35]. In dentistry, uses of nano technology include implant surface modifications, production of reinforced polymeric composites by incorporation of nano-sized particles, and caries prevention.[36]

Recent studies have suggested that incorporation of nano-sized particles or "nanoclusters" can improve the mechanical properties of dental restorative materials such as resin composites[37,38]. Following are the nanotechnology-improved GICs[39].

1. POWDER-MODIFIED NANO GLASS IONOMERS: Described for the first time by De Caluwé et al.,[40] it involves doping conventional GICs with nano-sized glass particles, which can decrease the setting time and enhance the compression strength and elastic modulus. The main advantages of decreasing setting times of direct restorative materials are enhanced ease of handling and manipulation.

a. MODIFICATION USING NANO-APATITE: Addition of nano-apatite or nano-fluoroapatite to the powder component of conventional GIC has a positive impact on the compressive, tensile, and flexural strengths of the set cement after being stored in distilled water for 7 days.[39]

b. MODIFICATION WITH NANO-SIZED HYDROXYAPATITE, CALCIUM FLUORIDE, AND TITANIUM DIOXIDE PARTICLES: It has been recently reported by Gu et al.[41] that the combined incorporation of HAp and zirconia (HAp/ZrO2) at concentrations of 4% volume to the GIC powder can improve the mechanical properties of the set GIC.[39]

2. NANO-FILLED RESIN-MODIFIED GICS: Resin-modified GICs also have a polymer resin component, which usually sets by a self-activated (chemically cured) or light-activated polymerization reaction.

To develop the mechanical properties of a resin composite with the anticaries potential of GICs, these were developed. However, compared to composites, resin-modified GICs have reduced mechanical properties, including brittleness and inferior strength along with aesthetics.[39] To overcome these drawbacks, there have been attempts to incorporate nano-sized fillers and bioceramic particles to RMGICs.[42,43]

Properties of nano-RMGICs are as follows:

A. BONDING OF NANO-RMGIC WITH TOOTH STRUCTURE: More ionic bonding with tooth rather than micromechanical retention, much akin to conventional GICs.[39]

B. MECHANICAL AND PHYSICAL PROPERTIES OF NANO-RMGICS: Poor flexural strength and fatigue limit in commercially available nano-RMGICs.[39] Perform the worst when mechanically tested on acid challenge.[39] Acidic environment may jeopardize the long-term survival rate of nano-RMGICs.

C. SURFACE MECHANICAL PROPERTIES OF RMGICS: The aesthetic properties of dental resin composite materials have been radically improved.[39]

D. FLUORIDE RELEASE FROM NANO-IONOMERS: Slightly increased fluoride release from nano-RMGICs at a pH of 4.[39]

CONCLUSION

Dental luting agents seal the interface between the restoration and the prepared tooth. This article tries to provide an insight into the various luting agents available for the clinician from the traditional water-based cements to the newer adhesive resins. Each luting agent has different physical, mechanical and biological characteristics resulting from its chemical structure .The pros and cons of the various luting cements have been discussed, and it can be safely concluded that no one material is perfect. With the plethora of newer luting agents flooding the markets, the practitioner must have sufficient knowledge to help choose the material for each clinical situation.

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