Selection of Dental Cements in Prosthodontics: A Review Paper

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Abstract

The cementation procedures of crown and bridge is consider as an important stage, however, the selection of the proper cement is a significant, because the quality of the cement affects the durability of the restoration. In modern dentistry, many cementing and luting materials have been introduced. These materials differ in their properties and applications. This makes selection of suitable cement for specific clinical situation often difficult.

The aim of this paper is to review and analyze dental cements used in dentistry, mainly in fixed prosthodontics in order to help practitioners select the most convenient cement material in dental practice. Moreover, this review paper will consider the structures, properties and the application of dental cements in specific clinical situations.

Keywords

Dental Cements; Luting Agents; Zinc Phosphate Cement; Zinc Polycarboxylate Cement; Zinc Oxide Eugenol Cement; Glass Ionomer Cement; Resin Cement; Cast Restorations; Solubility.

Introduction

Most luting agents used for cast restorations are dental cements. Luting cements are differentiated from other cements such as cement bases and liners, which are used in operative dentistry (1). The word luting is used to describe the use of moldable substance to seal a space or to cement two components together. Dental luting cements are materials used to provide attachment of indirect restorations and appliances to teeth.

In clinical dentistry, numerus indirect restoration such as metal; resin; metal-resin; metal ceramic and ceramic restorations; interim restoration; laminate veneer; post and core can be used for retention of restorations; and orthodontic appliances (2). The attachment between the casting restoration and the prepared tooth has been studied and the success of restoration cemented with traditional luting agent has been attributed to excellent adaptation between the interfaces (3).

Further, the primary function of dental cement is to fill the space between the dental prosthetic restoration and the prepared tooth or implant abutment since this will enhance the resistance to restoration dislodgement during function (4, 5). The long-term success of a restoration is strongly dependent on the proper selection and manipulation of dental cements. Thus, improper selection of cement for the dental prosthetic restoration and poor technique during cementation can lead to premature restoration failure. Loss of retention has been found to be one of the most common causes of restoration failure (6).

Despite all the improvements in physical and mechanical properties of traditional and modern dental cements, cement erosion is still accounted as one of the most causes of failure of dental cast restorations. Many studies proven that dissolution (rather than physical disintegration) of dental cement is the main cause of cement erosion (7). Most dental cements that are traditionally used for cast restorations consist of an acid combined with a metal oxide base to provide salt and water. During the setting reaction, the unreacted particles bind by a matrix of salt to harden the mass, and because these particles are ionic, they are susceptible to acid attack and therefore soluble in oral fluid (8, 9).

In clinical dentistry, practitioners search for the perfect dental cement. Numerous materials are available for cementation purposes such as zinc phosphate cement, zinc polycarboxylate cements, conventional glass-ionomer cement, resin-modified glass-ionomer luting agents, and resin luting agents. These materials have different mechanical and physical properties. Hence the proper choice of cement is largely determined according to the functional and biological demands of the particular clinical situation (1).

Dental cements should protect the tooth tissues, have high resistance to stress, tension and pressure, provide excellent bond between the tooth tissues and substances of fixed restoration as well as will prevent tooth decay on the cement contact surface (10). In addition, cements should be biologically compatible with pulp and have antimicrobial activity, provide a layer of minimal thickness, it should be easy to use, poorly soluble, transparent and radiopaque, and have optimal working and setting time. Dental cements should manifest high resistance to breakage, should have optimal wettability (low contact angle of wetting), sufficient viscosity for complete distribution and esthetic properties when applied together with restoration substance. Removal of excess cement should be as effortless as possible (11, 12).

Zinc Phosphate Cement (ZPC)

This cement has been used in dentistry for many years and has given a satisfactory results in many situations for more than a century since its development in 1880s (13). The liquid portion of zinc phosphate cement contains phosphoric acid, water and buffers, while the powder is composed of 90 % zinc oxide and 10% magnesium oxide. It should be regarded as the cement of choice for crown cementation.

Since the retention of the fixed prosthesis depends on the mechanical properties and solubilities of the cement, ZPC when manipulated properly, demonstrates a diametral tensile strength of 5.5 MPa, while its compressive strength is 104 MPa. Moreover, it has a modulus of elasticity approximately 13 GPa, which means that for a given load, it deforms less than a cement with a lower elastic module (2), this could be of benefit for clinical situations where large forces are expected to be placed on the dental prosthesis and therefore the cement as well. Even though its use has decreased clearly, significant clinical success makes zinc phosphate cement still readily available in many countries (1).

ZPC shows relatively low solubility in water; however, its solubility rate is greater in dilute organic acids (particularly citric acid) (3). ZPCs exhibit no chemical bond to the tooth structure as primary bonding occurs by mechanical interlocking at interface. This material sets by a long and gradual process, which may allow reasonable sitting for several minutes after mixing, that's if the cement is kept cool on a glass slab before placement. This property could be useful for complicated cases where several joined units need to be cemented at the same time (2).

Previous clinical trials documented in many literatures claim that zinc phosphate has no effect on dental pulpal tissue even though it posses a low pH of 2 after mixing of zinc phosphate (14). Pulpal irritation may be due to the bacteria that were left on the prepared tooth surface (14). However, clinically, tooth preparation with low residual dentine thickness, to be cemented with ZPC may suffer from sensitivity during and after cementation. Post-cementation sensitivity has been reported following the use of ZPC as the phosphoric acid can penetrate dentinal tubules in a dentine thickness of 1.5 mm. As a result, pulpal injury may occur if the underlying dentine is not protected against acid infiltration (15).

Attempts have been made to reduce this effect by using varnishes and calcium hydroxide suspensions. There is little evidence that long-term pulpal health can be maintained by such approaches, but providing enough geometric retention is present, ZPC appears to give a satisfactory performance when used with such techniques (16). Many researches have been done to estimate the toxic effect of ZPC particularly phosphoric acid and they prove that its effect on the dental pulp is clinically acceptable as long as good precautions are taken and over tooth preparation is avoided (17). This explains the success of use of this luting material over many years.

Zinc Polycarboxylate Cement (ZPCC)

ZPCC was developed in the 1960s and became the first cement to exhibit chemical bond to tooth structure (1). ZOCC is powder-liquid system and it is an acid-base reaction, its mixed using a 40% liquid polyacrylic acid or a copolymer of acrylic acid with other unsaturated carboxylic acids. The powder containing mainly zinc oxide with some magnesium oxide, and may contain small quantities of stannous fluoride (7).

Many studied reported that ZPCC may undergo plastic strain and deformation under dynamic loading after setting and this property limited its usage to single unit restoration and to short spam fixed partial denture cementation (18). The most important property of this class of cements is good biocompatibility with pulpal tissue and this is due to the rapid rise of pH after mixing and its lack of penetration into dentinal tubules as a result of the large molecular weight of polyacrylic acids (19). For this reason, it is used as temporary cement to prevent hypersensitivity of dentine after cementation in cases where the thickness of residual dentine is small. (19).

Moreover, the compressive strength of zinc polycarboxylate ranges from 67 to 91 MPa, while the tensile strength ranges from 8 to 12 MPa, as the latter is considered low (19). The working time of ZPCC is about 2.5 minutes that is considered shorter than that of ZPC, which is about 5 minutes. The shorter working time makes it difficult to use with multiple unit cementation. In addition, some researches demonstrated that the residual of zinc polycarboxylate cement is more difficult to remove than ZPC; also ZPCC may provide less crown retention when compared with ZPC (20).

Zinc Oxide Eugenol Cement (ZOEC)

ZOEC has excellent biological properties and can provide excellent marginal seal yet its physical properties is inferior to other classes of luting cements, which makes it an unattractive type of cement in dental practice. Many literatures and previous articles emphasize, that ZOE should be mainly used for cast restorations where good retention is expected and in clinical situations when biocompatibility and pulpal protection are required (21).

ZOEC Type I is used as temporary cementation of indirect restoration, whereas Type II is used for long-term application (21). Improved ZOEC has acceptable compressive strength, but its mechanical properties are somewhat inferior to other permanent luting cements. Moreover, ZOEC has a relatively short working time and it is difficult to manipulate in the oral cavity. In addition, the film thickness is high in some products and the practitioner may face difficulties to remove the excess cement (21).

Conventional Glass- Ionomer Cement (CGIC)

Conventional GIC was introduced as hybrids of silicate cement and polycarboxylate cement to have the property of fluoride release (from silicate cement) (22) and adhere to enamel and dentine (from polycarboxylate cement) (23). CGIC consists of a powder containing aluminosilicates with high fluoride content and a liquid component containing polyacrylic and tartaric acid. The result of the acid-base interaction of conventional GIC is unique, as the polyacrylic acid reacts with the outer layer of the powder particles resulting in calcium, aluminum and fluoride ions release (2).

The long-term absorption and excretion of fluoride are considered to be the main advantages and benefits of CGICs over ZPCs and ZPCCs (23). Conventional GIC bonds adhesively to dentine and enamel and because it inhibits infiltration of oral fluids at the cement tooth interfaces, it exhibits good biocompatibility. In addition, GIC has an anticariogenic effect because the fluoride release property (24). Moreover, many studies have reported that GIC has superior mechanical properties and high strength when compared with ZPCs or ZPCCs (1). Conventional GIC has a moderate compressive strength of 85 to 126 MPa and a low tensile strength of 6 to7 MPa. The physical properties of CGICs depends deeply on the powder to liquid ratio, as a result, the practitioner should follow the manufacturers mixing instructions precisely (23)

Many studies have demonstrated that the bond between dentine and CGICs can significantly be disturbed in the case of over drying of the dentine (25). Over drying can also result in post cementation hypersensitivity. In this manner, its recommended that wet dentine surface to be dried with cotton wool prior to cementation, this will improve the adhesion to dentine and limit post treatment hypersensitivity (25).

Even though some studies have reported that GIC cause sensitivity (26), others reported that post treatment sensitivity may result from desiccation or bacterial contamination of dentine rather than irritation by cement (27). To overcome post cementation sensitivity, dentists should carefully avoid the desiccation of prepared dentin surface (25). Also, glass-ionomer should be protected from moisture contamination since contact with water particles could change the setting reaction and may demonstrate early cement erosion (28). For all these properties, CGIC has become the cement of choice for luting cast crowns, fixed partial dentures, and orthodontic bands.

Resin- Modified Glass- Ionomer Cement (RMGIC)

RMGICs are the results of the continuous development in dental materials and clinical dentistry. RMGICs were introduced in the 1990s and they are considered as the hybrid version of conventional GIC. They have both desirable properties of glass-ionomer including florid release and tooth adhesion as well as high strength and low solubility of resin. In addition, this cement was manufactured to reduce the allergic sensitivity due to early moisture contamination and to reduce the solubility of the cement, both of which are considered to be disadvantages of conventional glass-ionomer cements (29).

This class of cement was introduced mainly for direct restorative purpose as it is cured by dual mechanism that includes acid-base reaction and light cure polymerization, thus facilities the working process. Like conventional GIC, RMGICs also maintain fluoride releasing properties and the desired adhesion as it exhibits 8 MPa bonding strength to tooth structure (25, 30).

Moreover, The physical properties of RMGIC is improved when compared to the conventional GIC, therefore it may be used for cementation of metal inlays, metal posts, cast crowns, and implant supported crowns and bridges. The compressive strength ranges from 93 to 226 MPa and the tensile strength ranges from 13 to 24 MPa (31). However, RMGICs should be avoided with all-ceramic restorations because fracture of some brands have been reported that is mainly because of their water absorption and expansion (32).

Resin Cement (RC)

RCs are considered as a superior class of luting cements that is used to bond indirect restorations. They have a wide range of application from inlays to prefabricated posts, fixed bridges, and orthodontic appliances. Resin composite cements are an alternative to the acid-base reaction, as they are based on bisphenol-a-glycidyl methacrylate (Bis-GMA) resin and other methacrylates that are modified from composite resin restorative materials. In addition, some resin cements contain ytterbium tri-fluoride or barium aluminum fluorosilicate filler, both of which are capable of releasing fluoride (33).

There are two main types of resin-based cements; a composite based and acrylic based (33, 34). Composite-based luting cements are insoluble and have a strong and durable bond to enamel (34). Usually, problems occur when cleaning up of excess materials, as the cement is difficult to remove from tooth and the prosthetic restoration. In that manner, excess cement should be removed immediately upon seating (34). Practitioners must not eliminate excess cement in the rubber stage, because some of the cement may be pulled out from under the cast restoration and the resulting voids at the margins could tremendously increase the susceptibility of secondary caries (34). The other main type is acrylic based luting cements, which are available in a constituents such as 4-META (4-methacryloyloxyethy trimellitate anhydride) which it tends to form a strong bond to dentine (33).

RCs are also classified based on the curing mechanism to light cured, self cured, and dual cured (chemically and by light activation). Self and dual cured resin cements tend to be used for all cementation procedures, while light cured resin cements are limited to porcelain veneers and ceramic restorations, the thickness of which doesn't exceed 1.5 mm so light could penetrate and polymerize the cement. Practitioners should be aware that dual cured composite cements display low bond strength and low micro hardening if left without light curing. Thus many literatures emphasized performing light curing of this class of cement especially at the adjacent margins (35, 36).

Recently, RCs were divided into two subgroups depending on the adhesive system used to prepare the tooth prior to cementation as one group utilizes etch-and-rinse adhesive systems, most commonly known as the total-etch and the other group utilizes the self-etching primers (37). In 2002, self-adhesive cements were introduced as a new subgroup of resin cements (37). The total-etch or the etch-and-rinse system is applied in three main steps. The first step includes application of the acid etching, rinsing, and gently drying of the tooth. The second step is application of the bonding agents and light curing. The third step is the application of the luting resin cement, placing of the indirect restoration and light curing. In the case of the self-etching system, the first acid-etching step and second bonding agent step are replaced with a single self-etching bonding agent step (38). This single self-etching bonding agent step combines the conditioner, primer and the adhesive all in one step and after that the luting cement is applied and the cast restoration is placed and light cured (38). In the case of self-adhesive cements, pretreatment of the tooth surface is not required. Once the luting self-adhesive cement is mixed, its application is done in a single clinical step followed by light curing. According to the manufactures', the use of a single step adhesive cement does not interfere nor removes the smear layer of the tooth, thus postoperative sensitivity is not expected (38).

RCs maintain high compressive and tensile strength, low solubility and have esthetic properties, which allows their application in cases where there are concerns about retention for example with esthetic ceramic restorations. RCs can also be used to fix all metal restorations, zirconia-based restorations, indirect composite restorations, metal and fiber posts, as well as implant-supported crowns and bridges.

Recommendations and Clinical Points

- ZPCs and CGICs are most frequently applied for crowns to be placed on retentive preparations where esthetic is not a problem.
- RMGICs are indicated for the cementation of cast restorations. They have good working properties and they are more translucent than ZPCS.

- ZPCCs are indicated for the cementation of crowns of usually sensitive teeth.
- Composite resin cements are indicated for situations where excellent retention is required, and where traditional geometric features are absent.
- Acrylic resin cements are indicated where there is a large amount of dentine available for bonding.

Conclusion

In clinical dentistry, varieties of cements are available as luting agents for cast restorations. The choice of dental cements has become more and more important, difficult and even confusing to the dental practitioners. Knowledge about the differences between cements will greatly contribute to the clinical success of the restorations.

Zinc phosphate cement, which can be manipulated easily, is still very popular and used in dental practice, despite of the irritating effects upon the dental pulp if proper protection is not provided. Polycarboxylate and glass-ionomer cements are considered as the replacement of zinc phosphate cement, particularly in cases where pulp postoperative sensitivity is expected. Certainly, developments in dental material and wide manufacturing of adhesive restorations promoted greater applications of adhesive cements. The resin-based cements, particularly the self-adhesive resin cements have become the cement of choice for fixation of ceramic restorations.

Lastly, it is clearly apparent that each clinical situation desires specific cement that satisfies all the ideal requirements. Dentists should give a special concern and consideration to the advantages and disadvantages of any dental cement and each situation should be appraised according to the biological and mechanical factors involved.

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