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Abstract

Glass ionomer (GIC), resin modified glass ionomer (RMGIC) and the newer self-adhesive resin base luting materials dominate the market for final cementation of indirect metal supported and metal-free restorations. Each class of material has definitive features and benefits and are selected based on the assessment of the dentist and the specific clinical condition and needs of the patient. This article will provide a review of these three classes of cements and illustrate the use of each class with three clinical case reports.

Introduction

Glass ionomer cements (GIC) were introduced by Wilson and Kent in 1969 in an effort to combine in a luting cement the translucency and fluoride release of a silicate cement with the tooth structure adhesion potential of polycarboxylate cement. The classic glass ionomer formulation consists of a powder composed of a calcium, strontium or lanthanum aluminosilicate glass with fluoride added and a liquid acid phase. The liquid is typically a mixture of poly acrylic acid and may contain itaconic, maleic or small quantities of other organic acids.[1] The dispensing of the powder and liquid components is critical as too much powder will increase viscosity and decrease working time and too much liquid will reduce the physical properties of the set material. As a result most manufacturers offer encapsulated formulas suitable for mechanical mixing.

The working time for glass ionomer cements is typically shorter than zinc phosphate or polycarboxylate cements. When mixed appropriately, the materials should have a glossy surface and should flow easily allowing complete seating of the restoration without having to exert firm and sustained pressure.[2] Conventional glass ionomers exhibit a characteristic "snap set" can be visually noted by the appearance of a dull finish on the surface of the extruded excess cement. Managing when to remove excess cement and how to protect the cement margin in the early stage of set has been somewhat confusing. The chemistry of traditional glass ionomers is dependent on the water balance of the newly set material as the GIC contains water and releases water during the setting reaction. In the early stage of the setting reaction exposure to water will cause erosive loss of material, typical of any acid-base setting chemistry.[3] However isolating the materials from moisture for too long a time can lead to dehydration of the cement with microcracks being formed in the material. Some have suggested transitional protection of the early setting material by using a varnish to cover the exposed surface.[1] Others[4] have suggested that excess cement expressed from the cementation procedure should be left in place for 10 minutes and that this prevents erosion of the material at the marginal interface as it is protected by material that will be removed. As a practical matter however Mount[2] suggested that modern glass ionomer cements are fast-setting and have a high resistance to water degradation within 5 minutes. In any event, whatever clinical technique is selected should not have the cement margin isolated from the oral environment for more than 10 minutes to prevent degradation due to the dehydration effect.[5]

While the mechanical properties of glass ionomer cements, especially the modulus of elasticity and abrasion resistance have been questioned, conventional glass ionomer luting materials are noted for two key clinical benefits; adhesion to tooth structure and a slow and sustained fluoride release. Chemical adhesion to tooth structure is achieved via a chelation reaction of the GIC matrix with calcium and phosphate ions in enamel and dentin. A key attribute of these cements is the ability to "recharge" the fluoride in the matrix of the material by use of topically applied fluoride.[6] The immediate and sustained release of fluoride has been shown to have clear cariostatic effects.[7]

Resin –modified glass ionomer cements (RMGIC) were developed to in an effort to retain the clinical advantages of GIC such adhesion to tooth structure and base metals, fluoride release and biocompatibility, while improving the mechanical properties and moisture sensitivity.[8,9] The deficits in abrasion resistance and mechanical strength in conventional glass ionomers are primarily due to the relatively weak hydrogen bonding (compared to covalent bonding) between the aqueous polycarboxylate and silica gels of the matrix. While details of the chemistry of RMGICs vary, the primary concept is to create two separate networks, one glass ionomer type permitting tooth adhesion and high fluoride release and the other an acrylic polymer type generating strength.[10] RMGICs have the clinical benefits of extended working time and increased mechanical strength while maintaining most of the positive features of conventional GICs.[11] Resin-modified materials consist of mixtures of an acid-degradable glass and a mixture of polyacid and water soluble poly acrylate monomers. Upon mixing the acid-base reaction starts the setting reaction and the monomeric components are simultaneously set via a free-radical polymerization reaction. The setting reactions result in an interpenetrating network of polyacrylate (such as 2-hydroxyethy methacrylate-HEMA) and polyacrylate salts. This chemical approach forms a covalently bonded three-dimensional network.[12] The visible light curing reaction reduces the erosion effect due to early exposure to moisture as well as the dehydration seen in the early setting reactions of conventional materials.

While it has been reported that fluoride release by RMGICs are quantitatively similar to conventional GICs[11] there is significant variability among RMGIC products and while a sustained and rechargeable release is present the amount of fluoride release is generally less in RMGIC materials compared to conventional materials.[13] It is not clear whether this generally lower level translates to a reduction in the anti-caries potential of RMGIC materials.

Conventional resin cements have superior mechanical properties when compared to GICs and RMGICs[14] and can provide increased retention in low-retention clinical situations.[15] However, conventional resin cements require the use of separate bonding systems for adhesion. The more complex steps in using a resin cement and adhesive can make the clinical technique more prone to error due to greater technique sensitivity.[16] This may be associated with a higher than desired incidence of post operative sensitivity especially in posterior teeth where isolation of the operative field is more difficult. Multipurpose resin-based luting materials with self-etching characteristics have been developed as so-called "self-adhesive" cements. These materials eliminate the need for use of a separate adhesive system to facilitate bonding of the cement to the tooth structure. These products are designed to combine the favorable characteristics of different cements into a single product which in theory minimizes the application mistakes induced by the technique issues of conventional resins and their associated adhesive systems.[17]

The development of these cements re-introduces the concept of using the smear layer as a bonding substrate but using novel formulations that have the capability of penetration through the smear layer into the underlying dentin substrate.[18] Preservation of the smear layer, in contrast to cements used in conjunction with etch-and-rinse adhesive systems, may be a key factor in eliminating post cementation sensitivity. Self-adhesive cements do not require any pre-treatment of the tooth surface their single step clinical application is more similar to zinc phosphate and polycarboxylate cement.[19] In addition these cements are formulated to have both self-curing and visible light curing polymerization mechanisms.

The composition of these materials differs from RMGIC formulations in several key ways. First, in addition to ion releasing glasses, conventional silanated composite resin glasses are included imparting greater mechanical strength. Second, the phosphoric acid groups are connected to the reactive carbon-double bonds of the acrylate component via a carbon backbone. Using this kind of multi functional monomer more fully integrates the polyacrylate salt into the interpenetrating network. These materials typically contain both chemical and light induced radical polymerization reactions. The reactive phosphoric acid esters are negatively charged and the bonding mechanism is via interaction with the positively charged calcium ions in enamel and dentin.[20]

Numerous studies have shown that cements of this type exhibit excellent bond strength to prosthodontic materials[21] and that cement marginal microleakage scores are equal to or better than well tried cement systems[22]. While promising results have been shown in some studies in the ability of these cements to bond to dentin there is great variation in bond test data.[23,24] It is generally conceded that adhesion values are greater when the cements have been exposed to visible light for curing compared to values generated when the cements are only auto-cured.[23] Enamel adhesion values are however consistently below that generated using conventional resin cements with enamel/dentin adhesive systems unless phosphoric acid conditioning is employed on enamel with the self-adhesive cement.[24]

The general consensus is that when cementing all-ceramic restorations, use of a resin cement is important for maximizing the resistance to fracture of these prosthodontic materials. One study showed equivalent fracture resistance of aluminum oxide crowns when cemented with a conventional or self-adhesive cement.[25] However aluminum oxide is a relatively high strength material and may not rely on the bonding and reinforcement of the cement as much as lower strength ceramics such as the very translucent high-leucite materials. For this reason, it is recommended that self-adhesive cements be avoided when placing all-ceramic restorations made from non metal supported feldspathic or high-leucite ceramics.[26] It appears that restorations made from higher strength materials such as lithium disilicate, aluminum oxide or zirconium oxide can be luted with these cements without increasing the risk of fracture failure.[27] Because of the significantly lower enamel adhesion inherent with these materials, primarily enamel supported restorations such as veneers should not be cemented with the self-adhesive systems unless steps are taken to treat the enamel with a procedure to increase the bond strength.

The selection of the most appropriate luting material is based on the clinician's evaluation of the clinical situation, the patient needs and the subjective preference the operator has for materials with specific handling characteristics. As a general statement GICs, RMGICs and self-adhesive cements can be used routinely for all metal supported restorations as well as for restorations fabricated from higher strength ceramics. The only relative contraindication for all three of these cements is when bonding feldspathic or leucite ceramics or when bonding to enamel is a paramount importance (such as when using a veneer). When considering applying these materials to specific clinical situations, each material has advantages that should be considered. Conventional glass ionomers have the highest and most sustained fluoride release but lack physical strength. Resin-modified glass ionomers have somewhat lower fluoride release but improved physical properties and compared to glass ionomers. Self-adhesive systems have the least anti-caries properties but the best physical properties and their intrinsic adhesion capability to dentin makes them attractive for preparations with less retention and resistance form than is considered ideal.

The following clinical cases illustrate the use of three cements representing each of these three cement categories. Riva Luting is a conventional glass ionomer, Riva Luting Plus is a resin-modified glass ionomer and seT is a resin based self-adhesive cement.

Clinical Case 1 - *Dr. Ara Nazarian*

The patient presented with discomfort in the lower left region of her mouth. Upon clinical examination, it was evident that teeth # 19 and #20 had large amalgam restorations that were fractured with recurrent decay (Figure 1-1). The radiographs on #19 showed recurrent decay beneath the restoration extending near the pulp. The patient complained of discomfort on biting hard foods with occasional sensitivity to cold. The diagnosis was determined to be recurrent caries on tooth #20. Tooth #19 was diagnosed with a pulpitis secondary to deep recurrent decay and tooth fracture.

The patient agreed to treatment, and was advised of all risks, benefits, and alternatives for care. The patient was anesthetized and amalgam removal was achieved using a carbide bur. The diagnosis of recurrent decay was confirmed. (Figure 1-2) Using direct composite material, tooth #20 was restored incrementally. Due to the extent of decay and deep crack on tooth #19, it was advised that the patient have endodontic therapy. (Figure 1-3) Root canal therapy was completed on this tooth (Figure1-4), and a core build up was placed using Riva Self Cure glass Ionomer material (SDI) (Figure 1-5). Once the core material was completely cured, the tooth was prepared for a full coverage crown using a chamfer diamond bur. (Figure 1-6) It was necessary to extend the crown margins subgingival in order for the margins to be on solid tooth structure since the decay had spread deeply below the gingival margin. An impression was made and a provisional restoration was placed. Two weeks later the patient retuned for placement of a porcelain fused to metal crown on tooth #19. The provisional restoration was removed and the preparation was inspected for final cementation. After a bite-wing X-ray was taken to confirm full seating of the crown and the contacts and margins verified.

Because of the moderate to high caries risk of the patient and the active subgingival margin the crown restoration was cemented using Riva Luting Glass Ionomer cement (SDI). (Figures 1-7 and 1-8) Riva Luting is a conventional glass ionomer cement with high fluoride release and excellent handling and physical properties.

Figure 1-1. Recurrent decay found radiographically under the amalgams in teeth #19 and 20. Tooth #19 is symptomatic and has evidence of fracture.

Figure 1-2. Following removal of amalgam and recurrent decay, it was determined that #20 could be restored with direct composite. Tooth #19 had significant decay.

Figure 1-3. Caries removal in #19 revealed tooth fracture and decay in close proximity to the pulp. Endodontic therapy was initiated.

Figure 1-4. Completion of endodontic therapy.

Figure 1-5. Core build-up using Riva Self Cure glass ionomer restorative.

Figure 1-6. Tooth prepared for full crown.

Figure 1-7. Loading crown with Riva Luting glass ionomer cement.

Figure 1-8. Final restoration.

Clinical Case 2 - *Dr. Scott Parker*

The patient initially presented with significant posterior attrition, with an anterior open bite and several discolored anterior teeth. Following a full occlusal analysis it was determined that the best approach would be orthodontic treatment followed by a full mouth reconstruction using porcelain fused to metal restorations in the posterior and all ceramic zirconia restorations in the anterior. The orthodontics was enhanced with maxillary and mandibular surgery prior to restoring the occlusion (Figures 2-1, 2-2, 2-3). The zirconia restorations combine excellent esthetics with high strength for the anterior restorations. The central incisors are shown in Figure 2-4 at the try-in. For final cementation for both the metal ceramic and zirconia restorations, Riva Luting Plus was selected for its excellent fluoride release, high strength, and good adhesion properties. In addition Riva Luting Plus a resin-modified glass ionomer offers extended working time ideal for cementing multiple restorations.

Figure 2-5 shows the central incisors at initial placement the cement excess evident. Figure 2-6 shows the ease of removing the excess with a dental explorer. The completed anterior segment is shown in Figure 2-7 and the completed maxillary and mandibular occlusal views are shown in Figures 2-8 and 2-9 respectively.

Figure 2-1.

Figure 2-2.

Figure 2-3.

Figure 2-4. The central incisors are shown at the try-in.

Figure 2-5. At initial placement the cement excess evident.

Figure 2-6. Ease of removing the excess with a dental explorer.

Figure 2-7. Completed anterior segment.

Figure 2-8. Completed maxillary occlusal view.

Figure 2-9. Completed mandibular occlusal view.

Clinical Case 3 - *Dr. Stephen D. Poss*

A 42 year old female presented with a MOD amalgam with rough edges on tooth #19. The entire mesial and distal lingual cusp were fractured. (Figure 3-1) With the existing fractures in the tooth the best treatment option was determined to be a full coverage restoration. The patient expressed a preference for a high strength metal-free crown material. Following informed consent, the patient was given anesthesia and the tooth was prepared for an all-ceramic crown. (Figure 3-2) A polyvinyl impression was taken. A bis-acrylic provisional was fabricated and temporary cement was used to place the provisional.

When the patient returned the zirconium oxide all-ceramic crown was inspected on the die for fit and shade inspection (Figure 3-3). After anesthesia was administered the provisional was removed. The temporary cement residue was removed and the tooth thoroughly cleaned. The crown was placed on the tooth to verify the fit and contacts. The all-ceramic crown was cleaned and prepared for cementation. Because of the posterior location of the tooth and the relatively short clinical crown leading to reduced retention and resistance, seT self-adhesive cement was selected for its high physical properties and bonding properties. This material is a is a self-etch, self-adhesive resin cement. It is a one step cement that leaves the smear layer intact and as such has minimal to no post-operative sensitivity. seT is light cured and self cured and can be used with porcelain fused to metal crowns, all-ceramic crowns including zirconia, and with fiber or metal post systems. seT is radiopaque and has a very low film thickness.

The seT capsule was activated with a Riva applicator (SDI) and placed in the Ultramat 2 amalgamator (SDI) for ten seconds. seT was then applied to bonding surfaces of the crown (Figure 3-4). The all-ceramic crown was seated with light pressure. After two minutes, the excess marginal material can be spot cured with a dental curing light for 2-3 seconds and the excess cement carefully removed (Figure 3-5). A final margin cure of 20 seconds on the buccal and lingual surfaces is done before the procedure is completed (Figure 3-6). When visible light curing is not used seT the self-curing time duration is 5 minutes.

Summary

Riva Luting, Riva Luting Plus and seT self-adhesive cements offer the dentist a wide range of utility for nearly all luting situations. Riva Luting offers excellent and consistent mixing stability, high fluoride release and the characteristic snap set of conventional glass ionomers. Riva Luting Plus is a resin-modified glass ionomer with excellent fluoride release, enhanced physical properties and extended working time for ease of operator use. seT is a unique self-adhesive resin cement with excellent adhesion to dentin and the convenience of dual-curing chemistry.

Figure 3-1. The patient presented with a complaint of a broken tooth on #19. The complete lingual wall of the tooth is fractured.

Figure 3-2. Full coverage, chamfer margin preparation for all-ceramic zirconia restoration.

Figure 3-3. Complete restoration check for fit contact and shade on the working model.

Figure 3-4. SDI self-adhesive cement seT being placed into final restoration from capsule mix/delivery system.

Figure 3-5. After seating the crown with firm pressure and waiting for 2 minutes, the excess cement was tack cured with a visible light for 2 seconds and the excess removed.

Figure 3-6. The final restoration in place.

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