Greg Gillespie DDS
Mark A. Latta DMD, MS
Lou Graham DDS

modern glass ionomers used as liners in the composite resin sandwich technique

glass ionomers

Greg Gillespie DDS Mark A. Latta DMD, MS Lou Graham DDS

Wilson and Kent introduced conventional glass ionomer cements in 1972.[1] They are derived from aqueous polyalkenoic acid such as polyacrylic acid and a glass component that is usually a fluoroaluminosilicate. In an acid-base reaction the metallic polyalkenoate salt begins to precipitate, gelation begins and proceeds until the cement sets hard. The setting reaction of glass ionomer cements is facilitated by the early release of calcium ions. In conventional glass ionomer formulas, the slower release of the aluminum ions is responsible for increased cross-linking, which significantly improves the strength over a period of several days. This improvement in physical properties is an important characteristic of these materials in their clinical use.[1] In the 1990's several faster setting, high-viscosity conventional glass ionomer cements became available for use as longer term restorative materials in higher stress bearing areas. These materials set faster and are of higher viscosity because of finer glass particles, anhydrous polyacrylic acids of high molecular weight and a high powder-to-liquid mixing ratio. The setting reaction is the same as the acid-base reaction typical of conventional glass ionomer cements.

Resin-modified glass ionomers also called "hybrid" ionomers were first introduced in 1992. These combine an acid-base reaction of the traditional glass ionomer with a self-cure amine-peroxide polymerization reaction. These light-cured systems have been developed by adding polymerizable functional methacrylate groups with a photo-initiator to the formulation. Such materials undergo both an acid-base ionomer reaction as well as curing by photo-initiation and self cure of methacrylate carbon-carbon double bonds. These materials represent an acid base reaction supplemented by a free-radical polymerization reaction usually initiated by photo-polymerization.

Both conventional and resin-modified materials have excellent physical properties suited for a wide variety of dental applications.[2,8] Glass ionomers have excellent fluoride release and are able to bond to both enamel and dentin during the setting process. The mechanism of bonding appears to involve an ionic interaction with calcium and/or phosphate ions from the surface of the enamel or dentin. Bonding is enhanced by treating the surface with a mild acid, cleaning but not significantly removing calcium ions. The ion exchange between the glass ionomer and the mineralized tooth structure is derived from the polyalkenoate chains entering the molecular surface of dental apatite, replacing phosphate ions. Calcium ions are displaced equally with the phosphate ions so as to maintain electrical equilibrium. This leads to the development of an ion-enriched layer of cement that partially penetrated into the tooth. The early acid reaction partially solvates the tooth surface allowing penetration of the glass ionomer gel. On setting the interpenetrated poly-alkenoic mass is integrated with the surface later of tooth creating a hybrid layer of glass ionomer with mineral apatite and in the case of dentin, collagen.[8,9]

The bonded glass ionomer also in theory will seal the cavity, protecting the pulp, eliminating secondary caries and preventing leakage at the margins.[6-10] The shear bond strength of conventional and resin modified glass ionomer cements to conditioned enamel and dentin is relatively low, varying from 5 to 18 MPa.[2] However, this bond strength is deceptive when compared to conventional resin based adhesives. Mechanically the shear bond test is more a measure of the tensile strength of the cement itself, since fractures are usually cohesive within the cement, leaving the glass ionomer attached to the tooth. In addition, glass ionomers are more dimensionally stable on setting and do not generate significant polymerization stress at the marginal interface unlike conventional resin systems. Glass ionomers perform in adhesive clinical trial models on par with many composite adhesive systems.

Glass ionomers are indicated for restorative indications, luting, sealants and as a base or liner. In 1977 McClean first recommended lining composite resins with glass ionomer cement.[1] In this technique, the glass ionomer would be placed to the dento-enamel junction and the composite resin placed over it. In effect this technique employs the glass ionomer as a dentin substitute. Subsequent to the placement of the liner, an adhesive material is used (either with phosphoric acid conditioning or by using a no-rinse self-etching adhesive) and the composite resin restorative is placed. While early composite resins did not have optimal physical properties for use in restoring posterior teeth, significant advances in resin technology were made in the early 1980's making the dentin/enamel adhesive the weak link in a resin restoration.[3] Since Buonocore first showed effective bonding to enamel using phosphoric acid in 1955, the problem in the 1980's and early 1990's was dentin adhesion. McClean's suggestion was a valuable technique as glass ionomers were able to bond to and seal dentin and could represent a practical way of reliably restoring posterior teeth with composite resin. It was shown that composite resin could be bonded to acid treated glass ionomer in 1985. [2]

This so-called "sandwich" of glass ionomer, dental adhesive and composite resin was proposed as an effective technique for both anterior and posterior resin based restorations by several clinicians as a means for pulpal protection from the acid-etch technique as well as a mechanism for sealing the cavity in the absence of good dentin adhesion available with the materials of the time. Two specific techniques were proposed; the first was the so-called closed sandwich. The glass ionomer was applied to a cavity where a complete enamel margin was available for bonding and sealing using the phosphoric acid etch technique. The glass ionomer would be placed to cover the dentin prior to the etching and bonding step. In clinical situations where a portion of the restoration would have a dentin only margin (as in a deep class II or a class V on a root surface), the glass ionomer would be placed to cover the dentin and become the external material at the dentin margin. This was termed an "open sandwich". [3-5]

As theoretical dentin bonding improvements in adhesives were made the use of liners of any kind under composite restorations was considered superfluous. Laboratory bond strength values of composite to dentin were approaching those of composite to enamel. However, the technique sensitivity of etch and rinse adhesive systems was not predicted from laboratory performance tests. These advanced adhesive formulas were sensitive to too much or too little residual moisture on the dentin surface. Clinically it became very challenging to determine the optimal dentin condition for good and durable dentin bonding. The “window of opportunity” for optimal bonding was very narrow and many clinicians experienced post-operative sensitivity, marginal breakdown and early restoration failure using the modern systems.

Numerous studies have shown superior performance of lined composite restorations compared to unlined restorations. Lined restorations exhibit less cuspal deflection from polymerization contraction stress than unlined cavities.[7] Marginal gap and marginal microleakage are significantly better using a glass ionomer liner compared to no liner under both open and closed sandwich restored cavities.[9,10] The growing evidence that glass ionmers have a key role in maximizing the success of composite resins, especially in posterior stress bearing situations has led to a resurgence of the sandwich technique for improving the service life of composite restorations.[8] The operator has both conventional and resin-modified glass ionomer materials to use to address the specific clinical situation.

Riva Self Cure is a high fluoride releasing, conventional glass ionomer designed for use as a restorative material in non-stress bearing situations and also as a dentin replacement material. Riva Protect is a conventional glass ionomer designed as a low viscosity material for use as a liner and sealant. It has very high fluoride release is radiopaque and also contain amorphous calcium phosphate (ACP) which enhances tooth structure remineralization. Riva Light Cure is a resin modified glass ionomer restorative material that can be visible light cured. It exhibits good fluoride release and has excellent mechanical and esthetic properties. The following clinical cases illustrate the use of these materials following the sandwich technique:

Clinical Cases

Case 1: Riva Self Cure - Fast Set

Fig. 1: A 54 y.o patient presented with deep decay both buccally and occlusally in tooth #31. Initial gross caries were removed with a high speed fissure bur, deep decay was removed with Komet’s Cerabur at a speed of 1000 rpms.

Fig. 2: The tooth was conditioned with Riva Conditioner for 10 seconds, rinsed and lightly air dried. Riva Self Cure fast set was mixed for 10 seconds. The capsule was placed in the SDI applicator and the glass ionomer material was injected into the preparation.

Fig. 3: After approximately twenty to thirty seconds, a composite instrument was used to remove the excess material. Within an additional 30 seconds the material began to set.
At this point it is recommended to stop condensing so that the material is allowed to fully set. Final set time is 4.5 minutes from mixing.

Fig. 4: After setting, the margins are cleaned with a diamond or carbide bur and an etch and rinse adhesive system was used prior to application of a resin restorative system. First phosphoric acid was applied for 10 seconds and water rinsed followed by application of a resin adhesive system according to manufacturer’s instructions.

Fig. 5-6: Following application of the adhesive system resin composite was applied to restore the buccal and occlusal surfaces of the glass ionomer lined restoration in multiple increments and visible light cured.

Fig. 7: The completed restoration:

Case 2: Riva Light Cure

Fig. 1: 40 y.o male presents with recurrent caries in amalgam restored teeth 18 and 19.

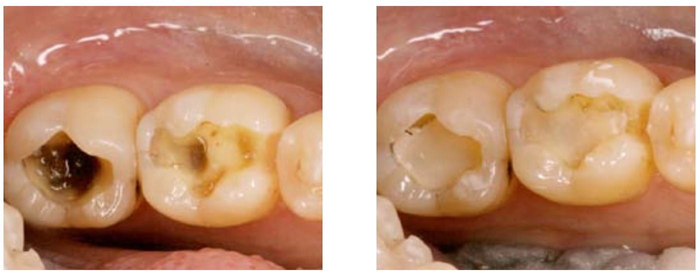

Fig. 2-3: Following removal of the amalgams, due to the depth of the cavities and the caries risk of the patient Riva Light Cure in a closed sandwich technique will be used as a liner.

Fig. 4: Using an acid etch technique, the lined cavity and cavo-surface areas were acid etched. An adhesive was then placed followed by a resin composite to complete the restoration.

Case 3: Riva Protect - Fast Set

Fig. 1: A 39 y.o female with a moderate caries risk presented with sensitivity to cold in tooth #14. Clinical and radiographic exam revealed possible failing amalgam restorations with recurrent caries.

Fig. 2: The amalgam recurrent caries was removed.

Fig. 3: Riva Conditioner was used to condition the dentin to optimize adhesion between the glass ionomer and tooth structure.

Fig. 4-5: Riva Protect powder and liquid were mixed.

Fig. 6: Riva Protect was placed into the cavity with an hand instrument.

Fig. 7: The excess glass ionomer was removed from the cavo-surface margins. The surface of tooth and glass ionomer was etched and an adhesive system applied.

Fig. 8: The restoration was completed with resin composite.

Summary and Conclusion

One of the many questions that is still debated in dentistry relates to the optimal current methods of restoring Class I and Class II restorations directly. There are many practitioners who adopt a resin only approach and there are others that follow a combination of glass ionomer/bonding regime. The latter approach employs the philosophy that in restoring teeth, one treats dentin and enamel as separate entities and with such an approach, maximizes different materials to achieve optimum long term success. In using the sandwich technique the operator selects a dentin substitute (glass ionomer) and an enamel analog (resin composite).

The consensus gold standard of adhesion dentistry is still considered to be the etch and rinse approach. Issues of sensitivity have become much the norm within the industry because the technique requires careful application and if done correctly can lead to excellent results. However the use of a glass ionomer liner is a more forgiving technique, especially in clinical situations where isolating the tooth is difficult. In addition, the evidence shows various degrees of micro-leakage and bonding strength degradation over time with pure resin composite systems. In addition, there are no caries inhibition properties incorporated into the current composite formulations.

It is the intent of this article to present a well studied and proven approach that combines glass ionomers and composites together to offer the practitioner a predictable and pragmatic approach to direct restorations. Glass ionomers in this technique are utilized for dentin replacement and offer the following characteristics:

- Long term fluoride release that can create fluoro-appetite in replacement of damaged dentin and have long term caries inhibition effects
- Similar thermal expansion properties as dentin
- Insulation from the affects of higher temperature from curing lights
- Insulation from the potential of uncured monomer from bonding agents that could seep into dentin tubules and create negative outcomes
- Less shrinkage and stress than composites
- A family of materials that have demonstrated less micro-leakage than adhesion products and thus ultimately creating better internal seals with dentin
- Overall a far less technique sensitive procedure that eliminates the issues of hydrophilic and hydrophobic properties of adhesion materials

References

1. McLean J.W. and Wilson A.D. The clinical development of the glass ionomer cements. 1977 *Aust Dent J.* 22(2) 120-127.
2. Sneed W.D. and Looper S.W. Shear bond strength of a composite resin to an etch glass ionomer. 1985 *Dent Mater*. 1: 127-128.
3. Boksman L, Jordan RE, Suzuki M. Posterior Composite Restorations. *Compend Contin Educ Dent*. 1984 May;5(5):367-70, 372-3.
4. Boksman L, Jordan RE, Suzuki M, Charles DH. A visible light-cured posterior composite resin: results of a 3-year clinical evaluation.*J Am Dent Assoc.* 1986 May;112(5):627-31.
5. Jordan RE, Suzuki M, Gwinnett AJ. Conservative applications of acid etch-resin techniques. *Dent Clin North Am*. 1981 Apr;25(2):307-36.
6. Aboushala A, Kugel G, Hurley E. Class II composite resin restorations using glass-ionomer liners: microleakage studies. *J Clin Pediatr Dent*. 1996 Fall;21(1):67-70.
7. Alomari QD, Reinhardt JW, Boyer DB. Effect of liners on cusp deflection and gap formation in composite restorations. *Oper Dent*. 2001 Jul-Aug;26(4):406-11.
8. Browning WD. The benefits of glass ionomer self-adhesive materials in restorative dentistry. *Compend Contin Educ Dent*. 2006 May;27(5):308-14.
9. Ratih DN, Palamara JE, Messer HH. Minimizing dentinal fluid flow associated with gap formation. *J Dent Res.* 2006 Nov;85(11):1027-31.
10. Schmidlin PR, Huber T, Göhring TN, Attin T, Bindl A.Effects of total and selective bonding on marginal adaptation and microleakage of Class I resin composite restorations in vitro. *Oper Dent*. 2008 Nov-Dec;33(6):629-35.