

Using Bioactive Materials to achieve Proactive Dental Care

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Resin bonding of the human dentition has become a “standard” in the United States and Canada. There are well over 80 different bonding systems on the market today. We have seen them evolve through multiple generations in an attempt to “simplify” the bonding process. But as these agents have simplified, many in our profession have seen many challenges “pop up”.

A significant number of reports in the literature have been showing that the “immediate bonding effectiveness of contemporary adhesives are quite favorable, regardless of the approach used (however) in the long term, the bonding effectiveness of some adhesives drops dramatically”.¹ The hydrophilicity that both etch and rinse and self-etch bonding agents offer initially in the dentin bonding process becomes a significant disadvantage in terms of long-term durability.²

It is this hydrophilicity of sim-

plified adhesive systems combined with other operator-induced challenges that contribute to these failures. Tay, Carvalho, Pashley, et al have reported repeatedly in the literature of this problem.^{3,4} They continue to report that these bonding agents do not coagulate the plasma proteins in the dentinal fluid enough to reduce this permeability. The fluid droplets contribute to the incompatibility of these simplified adhesives and dual/auto cured composites in direct restorations and the use of resin cements for luting of indirect restorations.

The term “water-tree” formation has been coined to describe this process, which originated from the tree-like deterioration patterns that were found within polyethylene insulation of underground electrical cables. It is now being applied to the water blisters formed by the transfer of dentinal fluid across the dentin-bonding interface. These “water blisters... act as stress raisers and form ini-

tial flaws that cause subsequent catastrophic failure along the adhesive-composite interfaces...”⁴

The previously mentioned plasma proteins are released by the dentin when subjected to acids and cause hydrolytic and enzymatic breakdown of the dentin and resin bonding agent interface.⁵ These enzymes are called Matrix Metalloproteinases (MMP). Currently there are only three methods of reducing these MMP's: 2% Chlorhexidine solutions that are used prior to application of bonding agents, Etchants containing Benzalkonium Chloride otherwise known as BAC (i.e. Bisco's Uni-etch products) and polyvinylphosphonic acid producing products (Glass Ionomer and Resin Modified Glass Ionomers).

Due to the short efficacy of these chlorhexidine solutions being used prior to bonding, this methodology has come into question as of late.⁶ Etchants with BAC have been shown to be valu-

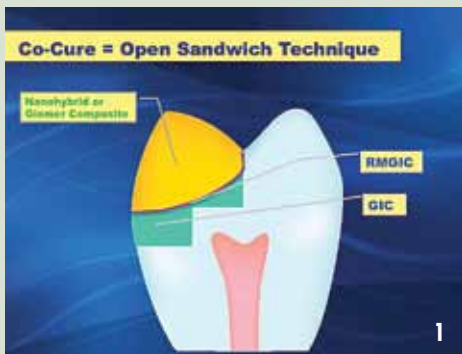


FIGURE 1: Co-Cure cross sectional diagram

FIGURE 2: The Co-Cure Technique, Step by Step

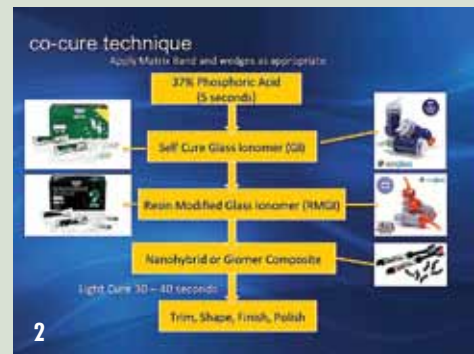


FIGURE 3: 2 1/2 year results Co-Cure procedures in 4 Quadrants of same patient

FIGURE 4: 32 month radiograph and photo of Co-Cure restored tooth # 30



able in the reduction of MMP's and should be considered in all bonding process.⁷ However, the most intriguing methodology of reducing MMP's and remineralizing tooth structure is with the use of Glass Ionomer Cements (GIC) and Resin Modified Glass Ionomers (RMGIC).

Glass Ionomer cements have long been used as a direct restorative material. Its early formulations made the material difficult to handle, and the break down of the material made it an undesirable solution in dental restoration. However, these materials, especially in today's formulations and pre-encapsulated presentations have many properties that make them very important in the restorative process. The work at companies like SDI North America (with their Riva product line), GC America, (with their Fuji product line) and VOCO (with their Iono product line) have continued to make great strides in improving these products for easier and more long lasting use

of GIC and RMGIC products.

First, these materials are bio-active, and up until recently they were the only materials with this property, that is they have the capacity to interact with living tissue or systems. Glass Ionomers release and recharge with ions from the oral cavity. This transfer of calcium phosphate, fluoride, strontium and other minerals into the tooth structure helps the dentition deal with the constant assault of the acidic nature of day-to-day ingestion of food and beverages and encourages remineralization, and the incorporation of phosphorous into the acid in today's GIC creates polyvinylphosphonic acid.⁸ This property of GIC makes them a major agent in the reduction of MMP formation, and thereby minimizing if not eliminating the collagen breakdown commonly found in many resin-dentin bonding procedures.⁹

Second, they bond and ultimately form a union with the dentition by chemically fusing to

the tooth. The combination of the polyacrylic acid and the calcium fluoroaluminosilicate glass typically found in GIC's reacts with the tooth surface, which releases calcium and phosphate ions, that then combine into the surface layer of the GIC and forms an intermediate layer called the "inter-diffusion zone".¹⁰ No resin bonding agents are required due to this chemical fusing to the tooth structure. This ion release helps inhibit plaque formation, and provide acid buffering capability helping to provide a neutralization effect intra-orally.

These GIC's additionally have very good marginal integrity with better cavity-sealing properties, have better internal adaptation and resistance to microleakage over extended periods of time, have no free monomers, can be bulk filled and offer excellent biocompatibility.¹¹ Another important consideration is that GIC's are moisture-loving materials, which makes them very sensible for use in the intraoral cavity. The transfer of



PHOTO 1—Class V lesion tooth # 18.



PHOTO 2—Placement of GIC to prepared area.

dentinal fluid from the tooth to the GIC essentially creates a “self-toughening mechanism of Glass Ionomer based materials...serves to deflect or blunt any cracks that attempt to propagate through the matrix (and)...plays an adjunctive role by obliterating porosities (which) delay the growth of inher-

ent cracks in the GIC under loading.⁴ The intermediate layer of the GIC provides flexibility during functional loading and acts as a stress absorber at the interface of the restoration and the tooth.¹²

Resin Modified Glass Ionomers (RMGIC) which are a hybrid of

traditional glass ionomer cements with a small addition of light-curing resin, exhibit properties intermediate of the two materials.¹³ This material has been shown to have properties similar to GIC, but with better esthetics and immediate light cure. RMGIC's have been shown to un-

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PHOTO 4—OB preparation tooth # 18.

PHOTO 3—Finished GIC restoration tooth # 18.

dergo slight internal fracturing from polymerization shrinkage, yet have an inherent ability to renew broken bonds and reshape to enforce new forms.¹² Application of RMGIC to all cut dentin in Class II composite restorations have been shown to “significantly reduce micro-leakage along (the) axial wall” of the restoration¹⁴

and helps prevent bacterial invasion of the restored tooth. RMGIC biomaterials are multifunctional molecules that can adhere to both tooth structure and composite resin providing an improved sealing ability by chemical or micro-mechanical adhesion to enamel, dentin, cementum and composite resin. They like GIC’s can be

bulk filled to reduce the amount of composite necessary to restore the cavity preparation and act as dentin substitutes in the restoration.¹⁵

The use of GIC and RMGIC in the restoration of posterior Class V restorations and conservative Class I restorations provides

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PHOTO 5—GIC restorative material placed in preparation and slightly overfilled.



PHOTO 6—Patient biting on plastic occlusal matrix.

many benefits. They are easy to place and reasonably forgiving even in a slightly moist environment. They should be placed in a moist but not wet environment, so familiarity with technique is imperative as it is with all dental restorations. I will often use Riva SC (SDI, North America) or Fuji 9 GP Extra (GC America) in posterior Class I and V restorations (Photos 1-7). Polishing and shaping of the materials must be done with water spray so as not to destroy the surface of the material (Photo 8). The use of RMGIC products, like Riva LC

or Fuji II LC, is great in bicuspid and anterior class V restorations, especially in high caries prone patients (Photos 9-12).

Class II restorations; however, have always presented a challenge to the clinician. If the operator wanted to use GIC or RMGIC, there was no easy way to do this that appeared to provide satisfactory results. It is with this in mind that the “sandwich technique” was developed. It was thought that using the properties of GIC to bond to the tooth and then applying resin bonding

agents and composite to the set GIC could help reduce sensitivity and bond failures typically seen in many resin bonded composite (RBC) techniques. Typically, the GIC is placed in the preparation, allowed to set, cut back to ideal form, and then bonded to with an RBC technique. However, the inability of the RBC’s to adhere to the set GIC often creates many failures. The materials by themselves are incompatible over the long term.

The modified sandwich technique evolved as a means to over-

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come this problem. By placing RMGIC over set GIC and then adding a RBC to that provided a better solution, but was as laborious and time consuming to do as is the sandwich technique.

In 2006, an article was published¹⁶ that in my opinion, has revolutionized the way I approach direct posterior restorations and today direct restorations as a whole. The article presented a radical approach to direct posterior restorations, called the “Co-Cure” Technique. This technique is defined as the simultaneous photo-polymerization of two different light activated materials which involves “the sequential layering of GIC, RMGIC and composite resin prior to photo-polymerization and before the initial set of the GIC (which) enables an efficient single visit placement of

a (direct) restoration...”¹⁶

In the Co-Cure Technique the composite restoration does not require a bonding agent, since the bonding agent is essentially the RMGIC. The RMGIC acts as the interface between the GIC and the composite material. It combines the GIC, RMGIC and composite in a way to form what can best be described as a “monolithic biomimetic restoration”. This restoration is an “Open Sandwich” type of Sandwich technique. That is the GIC component is exposed the to oral environment (Figure 1) at the gingival portion of the restoration. It is quickly and efficiently accomplished, and has significantly reduced postoperative sensitivity as compared to typical direct RBC techniques. I have been placing these types of direct posterior restorations since

2008. They have become the cornerstone of my practice.

THE TECHNIQUE (FIGURE 2):

After placement of an appropriate dental matrix, the technique incorporates the use of 37% phosphoric acid to prepare the tooth for restoration. The acid is essentially “flooded” into the preparation in a similar manner to doing a “total-etch” RBC. It is however, washed off after 5 seconds of placement. The tooth is then dried but not desiccated. The area remains slightly moist, since the GIC that will be placed next is hydrophilic.

Fill the preparation with the triturated GIC material up to the level of the DEJ, then immediately place the triturated RMGIC in a very thin layer to cover the GIC and walls of the preparation.

Finally place the composite over the previous materials to slightly overfill the preparation. With a large round burnisher dipped in an unfilled resin material (i.e. Riva Coat by SDI or G-Coat by GC), wipe away the excess GIC, and composite restoration material to create your margins and prevent ditching and white lines. The occlusal table of the restoration can then be compressed gently with a plastic occlusal matrix by either having the patient bite down onto or by pressing gently by the operator with his thumb or forefinger to improve the coalescence of the three materials. This can help reduce the time involved in creating the final occlusion of the restoration by creating a functional occlusal table.

The restoration is then cured for 30-40 seconds with an LED

curing light that is generating at least 1500 mw/cm². Appropriate light output is critical for all direct cured restorations, and assurance that appropriate output is provided by the curing light is needed for complete cure of ANY direct restoration. The restoration is then evaluated for complete cure, and then a layer of an unfilled resin is placed on the exposed GIC/RMGIC/composite complex and cured for an additional 10 seconds. The matrix band is removed, and the restoration is trimmed and polished, as any typical RBC restoration would be. I have found that an entire three surface posterior restoration can be accomplished in less than three minutes once the matrix has been placed. Typically the finishing of the restoration can also be done in less than three minutes. This makes the direct

posterior restoration quite efficient and beneficial to the clinician and the patient, since we are providing a restoration that will help enhance healing of the dentition and reduce recurrent decay and restorative failure.

An exciting advancement in bioactive materials is the development of Giomer (Shofu Dental: Beautifil II, and Beautifil Flow Plus) products. These Giomers are resin-based composites that contain pre-reacted glass ionomer particles (S-PRG). These particles are made of fluorosilicate glass reacted with polyacrylic acid (just like a GIC), just prior to being incorporated into the resin. This creates a new type of bioactive material. These giomer products, display properties similar manner to GIC's¹⁷: they release ions and recharge with ions from the



PHOTO 7—Final polished and trimmed GIC restoration tooth # 18.



PHOTO 8—Improperly finished GIC restoration (photo courtesy Dr. Brian Novy).



PHOTO 9—Class V lesion tooth # 12.

oral cavity, inhibit plaque formation, and neutralize and buffer the acids of the mouth.¹⁸ No other composite material has this property to date.

I use these Gioners instead of traditional nano-hybrid composites in my restorations because of these properties. They complete the entire biomimetic and bioactive nature of all the Co-Cure procedures that I create.

Another advancement that I have been working with in office is a product that is a Resin Modified Light Cured Bonding agent (SDI, North America: Riva Bond LC). This product is a specially formulated liquid RMGIC that can be used to bond composite restorations in the traditional sense, can be used in traditional sandwich and modified sandwich techniques and of course used in the Co-Cure technique. This concept is especially appealing

in light of the research that indicates RMGIC's provide quite good marginal seal when used as a bonding agent on cut dentin surfaces.¹⁴ I especially like to use it with the Co-Cure technique and when doing anterior restorations using the Gioners. I am able to get a completely biomimetic, bioactive restoration in both situations because of the bioactive nature of the materials used.

The technique for use of this RMGIC bonding agent with composite is as follows:

1. Etch with 37% Phosphoric acid for 5 seconds.
2. Wash, dry but do not desiccate.
3. Triturate and apply the RMGIC bonding agent with a micro-brush and cure for 20 seconds.
4. Place composite to fill the preparation and cure as appropriate.

When I use this material in the

Co-Cure technique I just substitute it for the traditional RMGIC material that I would have otherwise used.

It is my belief that using bioactive materials in the provision of care for my patients has been paramount to the success of the care I have been providing. In this way I have provided ways to heal the dentition, enhance the restoration and improve the health of my patient. I believe we are on the doorstep of further bioactive material advancements and that learning and incorporating these restorative materials into the day-to-day provision of care will continue to help our patients, our practices and our profession. **OH**

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PHOTO 10—Placement of RMGIC restorative material.



PHOTO 11—Initial trimming and shaping of RMGIC restoration.



PHOTO 12—Final polish tooth # 12.

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