Broadening the Spectrum of Use for Glass Ionomer Restorations

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Disclosure: Dr. Ward has lectured for GC America and received products for the procedures shown from the manufacturer.

INTRODUCTION

The demand for economical direct tooth-colored restorations has never been greater. Patients want restorations that match the original appearance of the tooth and do not contain metals or chemicals they find objectionable. Well-placed composites are showing improved lifetimes. Challenges with composite restorations are often related to operator errors. Composite restorations are technique-sensitive, and attention to detail is paramount for success.

Direct Composite Challenges

Postoperative sensitivity remains a challenge with direct composite restorations. Dentists using the total-etch approach to dentin bonding must be sure to re-seal the opened dentinal tubules with resin. Self-etching dentin bonding systems ameliorate the sensitivity issues but often have challenges at the enamel/composite resin interface since an ideal etching pattern may not be present for proper resin infiltration into the enamel rods. Recurrent decay has been reported more frequently with composite restorations. Microleakage is a problem, especially on cervical dentin margins. Voids between the restoration and tooth, or within restorations, can be a problem if the composite material is not properly adapted to the preparation or gaps occur between different layers of composite buildups. Air voids may be present within the material as provided by the manufacturer. Moisture control is also critical when placing composite restorations. Though the use of a rubber dam has been strongly recommended, it has been observed that a significant number of clinicians do not routinely use rubber dam isolation. Proper dentinal tooth surface moisture is important with most bonding systems, yet the definition of ideal moisture and how to achieve it is quite varied. Polymerization shrinkage and the associated polymerization shrinkage stress create tension at the interfaces, or within the entire tooth (Figure 1). Differences in expansion and contraction rates among composite resin, enamel, and dentin create tension within the tooth when hot and cold substances are introduced into the oral cavity and during occlusion. So much potential for stress is built into the composite resin restorative system that great effort has been made by manufacturers to engineer the materials to compensate.

The bond between the composite resin and the dentin surface may not remain stable. Hydrolyzation through the hybrid layer may destabilize the bond. Collagen degradation from matrix metalloproteinases (MMPs) and other enzymes may deteriorate the bond. The initial high dentin bond strengths may succumb to significant degradation and ultimately fail.
Dentists need more reliable, simpler ways to restore teeth, with methods that are more forgiving and less affected by the precise way they are manipulated and placed. Ideally, the protocol would be less dependent upon ideal surface moistness, proper timing, correct number of coatings for a particular bonding agent, adequate evaporation of the dentin bonding agent solvent after placement, proper layering geometries, and thicknesses of materials. Adequate curing light output from properly positioned or maintained lights, as well as proper finishing and polishing techniques, would be less of a factor. With all these protocols being manufacturer and/or material specific, it is not surprising that we see failures with direct composite restorations.

**History of Glass Ionomers**

Glass ionomer (GI) restorative materials were first developed in the 1970s in Great Britain. Improvements were made to the setting reactions, and they were introduced and manufactured by companies in Europe, Asia, and North America. Initial formulations were moisture sensitive, slow setting, and produced postoperative sensitivity. Many dentists tried these materials with less-than-successful results and then abandoned their use. Their initial reputations had been tarnished and with the advent of new and improved dentin bonding agents, these materials were nearly forgotten.

In the 1980s, modifications were made to GIs with the addition of resins within the formulations to produce resin-modified GIs (RMGIs). They set by 2 reactions: an acid-base typical GI reaction and a resin type polymerization reaction. These materials were better accepted due to their resin-like setting qualities and improved aesthetic appearance. Their use became popular as a liner, base, and cement. They had distinct advantages over composite resins with significantly reduced postoperative sensitivity, fluoride release, better retention, and ease of use.

In the meantime, improvements were made to the original GI formulations. Setting times were decreased and wear resistance was improved. The materials became more aesthetic than previous versions. Postoperative sensitivity due to water imbibition was reduced. Available and sustainable fluoride release was increased. Finally, ease of use was also improved. Today, GIs have a variety of forms including bases, liners, cements, sealants, and restorative materials.

**Advantages of Glass Ionomers**

There are 2 distinct materials within the GI family: GIs and RMGIs. This article will only discuss the clinical use of GIs.

*GIs set by an acid/base reaction*—Ionic bonding occurs between the negatively charged carboxyl ions of the GI and the positively charged calcium ions of the tooth surface. This bond is quite stable and not degraded by the usual fluids or enzymes that affect resins. The dentinal tubules are never fully opened during the process, so the likelihood of postoperative sensitivity is reduced. Fluoride release and uptake is dynamic throughout the lifetime of the restoration. When exposed to acid attack, fluoride ions are released, and when exposed to fluoride ions, there is an uptake. GIs are antibacterial. There is no polymerization shrinkage because no polymerization occurs with these materials; rather a setting reaction without shrinkage. GIs can be added in bulk since there is no need to add in layers to avoid polymerization shrinkage stress or to compensate for the inability of a light to penetrate deep areas of a restoration to initiate the polymerization reaction.

**Improved Glass Ionomers Restorative Systems**

New GI restorative materials have been introduced with improved filler loading, decreased wear rates, and increased
fluoride release. A restorative system (EQUIA [GC America]) has been recently introduced (Figure 3) to expand the indications for GI restorative materials to Class I restorations, nonstress-bearing Class II restorations, and stress-bearing Class II restorations, where the isthmus is less than half of the intercuspal width. These are in addition to the previous indications for intermediate restorations, Class V restorations, root surface restorations, and core buildups. The system incorporates the final placement of a filled resin coating over the surface of the set, adjusted, and dried GI restoration (Figure 4). The coating of the set GI with a filled resin imparts many advantages. First, the wear rate of the filled resin is less than GI, reducing wear as long as the sealant remains in place. Secondly, this material, as is typical with GIs, continues to set and mature for a period of months. The material is susceptible to loss of water during this setting period, so if moisture can be maintained during this time, the material will become stronger and will further increase in strength once the coating wears away and the material is then exposed to saliva. These restorations can be of great benefit for high caries-risk individuals, such as older patients predisposed to xerostomia from taking multiple medications. Patients with rampant caries, due to genetic or environmental factors, can benefit as well.

**Challenges**

There has been reluctance by some to embrace the GI family of materials. They are concerned about some physical properties that are inferior to composite resin; however, they overlook other properties that are superior. GI materials wear more than composite resins, have a lower compressive and tensile strength, and do not have an initial bond strength to dentin as great as properly placed resin bonded composite restorations placed in dentin at an ideal depth. Their weaknesses may be more than compensated with an absence of setting-shrinkage stress, a similar coefficient of thermal expansion to tooth, fluoride release, and the ability to restore a tooth without inducing high internal stresses. Comparing more wear on the occlusal surface of GI restorative material to the loss of an entire cusp of a tooth due to polymerization shrinkage stress from a composite resin, the GI restoration may ultimately leave more functional tooth volume (Figure 5).

**Glass Ionomers’ Restoration Lifetimes**

The question arises as to how long direct GI restorations last. One study cited a 92% success rate after 2 years, and a 65% success rate of Class I restorations after 10 years. The same study cited an 86% success rate after 2 years, and a 30% success rate of Class II restorations after 10 years. A meta study analyzed the results reported in 29 different papers and cited an 80% success rate of Class I GIs after 5 years. These studies show similar success rates when placed under ideal clinical settings compared to compromised settings. Figure 6 shows 4 large Class II restorations that had been in the mouth for 5 years. They all showed surface wear but were functioning well in difficult situations.

Success is often a factor of the size of the restoration with the most common mode of failure as fracture. Worn or fractured restorations can often be left intact and covered...
with traditional composite restorations. Rarely do GI restorations completely dislodge or show recurrent decay with Class I or II restorations, so the material can serve as an excellent base for a future composite restoration or indirect restoration.

**CASE REPORTS**

**Case 1**

Class II Composite Restoration With Multiple Cracks—A patient presented with visible interproximal decay. Cracks had developed along the margins and extended down the mesial and distal surfaces (Figure 7). The patient was anesthetized and the tooth excavated. A crack was discovered along the pulpal floor that extended from mesial to distal (Figure 8). Further excavation was halted to avoid possible pulpal exposure. When the patient was informed that a crown would ultimately need to be placed, she asked if it would be possible to delay an indirect procedure by using a direct restoration. Concern about polymerization shrinkage stress causing pain upon chewing and ultimately the loss of the buccal cusp eliminated the use of composite resin. The placement of bulk placement GI restorations is easier and, in the author’s experience, more predictably effective.

**Clinical Protocol**—A sectional matrix was placed (V3 Sectional Matrix System [Triodont]) and the enamel conditioned with phosphoric acid (Uni-Etch with BAC [BISCO Dental Products]) (Figure 9). Next, the dentin was conditioned with polyacrylic acid (GC Cavity Conditioner [GC America]), then the surface was washed and any excessive moisture removed. The GI capsule (EQUIA Fil [GC America]) was activated and mixed with a triturator and placed in the tooth (Figure 10). The restoration was allowed to set for 2.5 minutes, and then the matrix and retainer were removed. Gross shaping was performed with using a diamond bur (Piranha No. 379-023VF [SS White Burs]), the occlusion adjusted, a band placed to separate the teeth, the surface dried, and a surface sealant placed (EQUIA Coat [GC America]) and light cured (Figure 11). The patient reported no signs of postoperative sensitivity to hot, cold, or chewing with the completed GI restoration (Figure 12).

**Case 2**

Class II Amalgam Restoration With Significant Cracks—A patient presented with visible decay under an existing restoration (Figure 13). The patient was anesthetized and the old restoration was removed. The caries was removed using a slow-speed handpiece and with a spoon excavator. Cracks within the dentin were then clearly visible (Figure 14). It was determined that the best treatment would be to leave the cracks since they might extend into the pulp. The patient was informed that the ideal treatment would be to build up the tooth.
with a base and to place a crown over the tooth to help control the spreading of the crack under further occlusal loading. Citing financial reasons, the patient did not wish to have her tooth restored with an indirect restoration.

Direct aesthetic choices included a composite resin restoration, a sandwich technique with a GI base covered with a composite restoration, or a GI restoration. Concern about polymerization shrinkage stress creating tension between the buccal and lingual cusps resulting in the entire fracture of the buccal cusp eliminated the composite option and well as the sandwich technique. It was decided that placing a restoration that was less likely to result in the loss of the entire buccal cusp was most important.

Clinical Protocol—Sectional matrices were placed (Figure 15) (V3 Sectional Matrix System), the enamel surface conditioned with phosphoric acid (Uni-Etch with BAC), and the dentin surfaces conditioned with polyacrylic dentin conditioner for 10 seconds (GC Cavity Conditioner), washed, and air blown to achieve a moist surface. Next, the GI restorative material (EQUIA Fil) was quickly placed in one increment (Figure 16). The restoration was allowed to cure for 2.5 minutes. The retainers and bands were then removed, and preliminary shaping was performed on the occlusal and interproximal areas. Articulating paper was used to refine the occlusion. A metal band was placed around the tooth, the tooth dried, and a surface sealant (EQUIA Coat) was placed and light cured. The amalgam restoration on the adjacent tooth was removed and restored with a conventional composite restoration since no significant cracks were noticed (Figure 17).

Case 3
Restoration Under a Crown—A patient presented with a failing amalgam restoration. The tooth had been sensitive upon chewing (Figure 18). Insufficient tooth structure remained for a direct restoration, so the tooth was treatment planned for a crown. The patient returned, was anesthetized, a quick crown preparation performed, and the old restoration and decay removed. A crack extending from the mesial to the buccal was noticed along the pulpal floor (Figure 19). A copper band was placed to confine the material. The tooth was conditioned with polyacrylic acid (GC Cavity Conditioner), washed, and excess moisture removed. A GI restorative material was triturated and placed into the tooth. A gloved finger compressed the material into the tooth for 2.5 minutes during setting (Figure 20). The band was removed and final preparation was performed (Figure 21). A temporary was placed, and the patient subsequently returned for the crown seating. At the seating appointment, no anesthetic was required and the patient reported no postoperative sensitivity.
**DISCUSSION**

**Core Buildups**

Core buildups are an important foundation for a crown. Often, the old restoration is removed to excavate decay or to ensure that there is no decay present underneath. Since the preparation is often quite deep, materials and methods should be used to reduce the likelihood of pulpal sensitivity, reversible pulpitis, and especially irreversible pulpitis.

Placing amalgam cores generally requires extra visits since the material must be left alone to set. Amalgam is metallic and therefore conducts hot and cold stimuli. Amalgam also does not inherently bond to dentin, or to underlying liners or bases, so retention is often primarily dependent upon undercuts.

Composite cores with total-etch bonding agents are more susceptible to postoperative sensitivity due to technique sensitivities.\(^{24}\) Composite cores with self-etching bonding agents reduce the sensitivity, but unfortunately do not reliably bond to self-cure or dual-cure composite materials.\(^{25,26}\) Light-cured composite cores need to be layered, taking more time, and are accompanied by polymerization shrinkage stress. The important interface between the resin bonding agent and the dentin is subject to degradation from hydrolyzation and MMPs.

Many factors are important in the retention of a crown with a buildup. It is the weakest link that breaks. Amalgam may possess the highest material strengths of the direct core materials, but it does not adhere to the tooth. Composites have superior compressive, tensile, and flexural strengths to GIs.\(^{27}\) If placed ideally in shallow dentin, their initial bond strength surpasses GIs. The challenge is that great variability exists between dentin bond strengths from technique nuances. Deep dentin contains less intertubular dentin surface area, more and larger diameter dentinal tubules, and greater outward interpulpal fluid pressure, resulting in lower bond strengths.\(^{28}\)

Destructive fluid and enzymatic forces can diminish their bond strengths to dentin. GI dentin bond strengths have less variability, regardless of the depth, surface moisture, or operator technique and, furthermore, the bond strengths generally do not diminish throughout time.

The angle in which the forces will be exerted is important when making clinical material decisions for core buildup use. In situations where the forces are primarily parallel to the long axis of the tooth, such as in posterior teeth, the critical weaknesses will often be retentive forces that are likely to dislodge a crown. The weakest link may be adhesive between the dentin and the core or the core/tooth structure and the intaglio surface of the crown. In areas where the forces are oblique or perpendicular to the crown, such as in anterior teeth, the weakest link may be cohesive failure within the core. For this reason, GI buildups are best suited in the posterior area with adequate tooth structure remaining. In the anterior region, composite resin cores are preferred due to their increased flexural strength, better withstand the lateral forces of occlusion.

It has been observed clinically that crowns sometimes come loose with the amalgam or composite core completely attached to the crown. It also has been observed that posterior crowns rarely come loose with a GI core partially or fully attached to the crown. This would indicate that the weakest link was adhesive, not cohesive in these situations.

**CLOSING COMMENTS**

High strength and low wear are important properties for any restorative material; however, there are other factors that must be considered. The ability of a material to consistently adhere
throughout time, to reduce postoperative sensitivity, to not shrink upon setting thereby creating internal stress, to expand and contract at a rate similar to tooth structure, to be able to be placed in bulk, and to be technique insensitive are all attributes that should be evaluated. Even though the manufacturer has limited the indications for direct placement of definitive restorations to small restorations in nonstress-bearing areas, the author believes that the indications should be broadened to include the concept of its use for “long-term interim restorations.” This expanded use should allow dentists to save teeth when patients cannot, or choose not to, have indirect restorations placed.

The term permanent restoration is a misnomer. With most patients, given enough time, many restorations will eventually need to be replaced, so the concept of a restoration “lifetime” is essential. GI restorations will never completely replace composite resin restorations; however, they serve as another useful material in the dentist’s armamentarium, especially in patients with high caries risk. GI core builds should be considered in posterior teeth with adequate tooth structure remaining. The advantages of ease of use, reduced postoperative sensitivity, reduced technique sensitivity, a lifetime consistent bond to dentin, and fluoride release, preclude their increased use.

In closing, what once may have been considered an inferior material may actually serve to be a much better overall material in many situations. The use and varied applications of GIs needs to be revisited.

REFERENCES

June 30, 2006; Brisbane, Australia. Abstract 2076.


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POST EXAMINATION QUESTIONS

1. Dentists using the total-etch approach to dentin bonding must be sure to reseal the opened dentinal tubules with resin.
   a. True b. False

2. Recurrent decay has been reported more frequently
   with composite restorations, and microleakage is still a problem, especially at the cervical dentin margins.
   a. True b. False

3. It has been observed that a significant number of clinicians routinely use rubber dam isolation.
   a. True b. False

4. Collagen degradation from matrix metalloproteinases and others enzymes may deteriorate bond strengths.
   a. True b. False

5. Even the initial glass ionomer (GI) formulations were not moisture sensitive and produced no postoperative sensitivity.
   a. True b. False

6. In the 1980s, modifications were made to GIs with the addition of resins within the formulations to produce resin-modified GIs (RMGs); these materials were better accepted due to their resin-like setting qualities and improved aesthetic appearance.
   a. True b. False

7. GIs release fluoride ions, but are not considered truly antibacterial.
   a. True b. False

8. A restorative system (EQUIA [GC America]) has been recently introduced to expand the indications for GI restorative materials to Class I restorations, nonstress-bearing Class II restorations, and stress-bearing Class II restorations, where the isthmus is less than half of the intercuspal width.
   a. True b. False

9. GI materials wear less than composite resins, and they have a higher compressive and tensile strength than composite resins.
   a. True b. False

10. A meta-study analyzed the results reported in 29 different papers and cited an 80% success rate of Class I GIs after 5 years.
    a. True b. False

11. Composite cores with self-etching bonding agents reduce sensitivity, but unfortunately do not reliably bond to self-cure or dual-cure composite materials.
    a. True b. False

12. It also has been observed that posterior crowns often come loose with a GI core partially or fully attached to the crown.
    a. True b. False
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ANSWER FORM: VOLUME 33 NO. 12 PAGE 62

Please check the correct box for each question below.

1.  ☐ a. True  ☐ b. False

2.  ☐ a. True  ☐ b. False

3.  ☐ a. True  ☐ b. False

4.  ☐ a. True  ☐ b. False

5.  ☐ a. True  ☐ b. False

6.  ☐ a. True  ☐ b. False

7.  ☐ a. True  ☐ b. False

8.  ☐ a. True  ☐ b. False

9.  ☐ a. True  ☐ b. False

10. ☐ a. True  ☐ b. False

11. ☐ a. True  ☐ b. False

12. ☐ a. True  ☐ b. False

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