

Shear Bond Strength Evaluation of Resin Composite Bonded to GIC Using Three Different Adhesives

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Clinical Relevance

The bond strength of resin composite to glass-ionomer cement can be enhanced when a self-etching primer is employed over unset GIC or when a glass-ionomer based adhesive is employed over set GIC when compared to using a total-etch adhesive.

SUMMARY

The current study evaluated the bonding ability of composite to glass ionomer cement (GIC) using three different bonding systems. One hundred samples of com-

posites bonded to GIC were prepared and divided into five groups. In Group A, the composite was bonded to GIC after the initial setting of the GIC being employed as a total-etch adhesive. In Group B, the self-etch primer was employed to bond composite to GIC before the initial setting of the GIC. In Group C, the self-etch primer was employed to bond composite to the GIC after the initial setting of the GIC. In Group D, the GIC-based adhesive was employed to bond composite to the GIC before the initial setting of the GIC. In Group E, the GIC-based adhesive was employed to bond composite to the GIC after the initial setting of the GIC. Shear bond strength analysis was performed at a crosshead speed of 0.5 mm/minute. The results were tabulated and the statistical analysis was performed with one-way ANOVA; the Tukey's test showed that the bond strength of composite to GIC was significantly higher for the self-etch primer group employed on unset GIC and the GIC-based adhesive group employed on the set GIC for bonding composite to GIC.

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INTRODUCTION

The improved performance of resin composites and the increasing demand for esthetic perfection has encouraged more clinicians to select resin composites for posterior restorations as a possible alternative to amalgam. However, the clinician should be aware of certain disadvantages when using a resin composite, such as polymerization shrinkage, associated microleakage, pulpal irritation and lack of anticariogenicity.¹

Laminate restorations play an important role in restorative dentistry, wherein glass ionomer cement (GIC) is placed below and a resin composite is placed over it. The superior micromechanical bond of resin composite to acid-etched enamel, the bond strength of glass ionomer to dentin and the ability of glass ionomer to release fluoride when in contact with oral fluids, combined with its low solubility, make the combination of these two materials a prudent step in improving clinical success.^{2,3} This technique was developed by McLean and others in 1985; they used the dentin adhesive properties of glass ionomer cements (GICs) to seal cavities and reduce microleakage.⁴ This technique benefits from the advantages of GIC fluoride release combined with esthetic resin material to enhance clinical serviceability.⁵ However, the bond between conventional GICs and resin composite is limited due to a lack of chemical bonding between the two materials and also the low cohesive strength of glass ionomers. This could be attributed to the difference in setting reactions between dental composites and conventional GICs.⁵ Furthermore, failure also occurs due to sensitivity of the GIC to moisture and its progressive loss following acid etching.⁶ Moisture contamination during the initial setting of GICs can cause dissolution of the weak calcium-polyacrylate chains, which can degrade their physical properties. In order to prevent moisture contamination during the rinsing procedure, it is mandatory to allow the initial setting of the glass-ionomer prior to the etching procedure. Clinically, this can be achieved by waiting for two-to-seven minutes for the initial setting of the GIC to be complete before starting the etch and rinse procedure.

Detailed clinical techniques for bonding glass ionomer to dentin, followed by etching the enamel margin and glass ionomer lining, then bonding resin composite to etched enamel and glass ionomer have been described.⁷ The success of the resin composite-glass ionomer laminate restoration depends on the strength of the bond of the glass ionomer liner to dentin and the strength of the bond between the glass ionomer liner and the resin composite.⁷ Agreement as to the optimum etching time of the glass ionomer has yet to be standardized. A 30-second or less etching time has been proposed in one study,⁸ while another study showed the average bond strength of 1,159 psi between composite and glass ionomer etched for 60 seconds.⁴ A third study reports no

significant difference between 30- and 60-second etching times.⁶ However, surface deterioration of glass ionomer cements following acid etching for longer than 15 seconds has been noted and recommendations for limiting the etching time have been made based on these SEM evaluations.⁴ A study by Magnum and others recommended a 15-second etching time before application of the bonding agent.⁵

The time-tested protocol of glass-ionomer composite bi-layered restoration has one clinical drawback. Due to the use of 37% phosphoric acid to etch glass ionomer, there is a need to rinse the acid before applying the bonding agent. In order to prevent moisture contamination during the rinsing procedure, which may affect the integrity of the glass-ionomer, it is mandatory to allow the initial setting of the glass ionomer before the etching procedure. This is clinically verified with the help of a sharp explorer⁵ after waiting for 5 minutes and 20 seconds (manufacturer's instructions, GC ASIA Tokyo, Japan).

Since this procedure requires a waiting period, this technique is not popular among restorative dentists. The recent development of adhesive systems, including self-etch primers and glass-ionomer-based adhesives, might overcome this disadvantage, as they do not require the etch-and-rinse procedure.

Self-etching systems combine the functions of primer and adhesive components and do not need an "etch-and-rinse" phase, which not only decreases clinical application time, but also significantly reduces technique sensitivity. Another important advantage is that the infiltration of resin occurs simultaneously with the self-etching process, by which the risk of discrepancy between both processes is low or non-existent.⁹ The self-etch effect should be ascribed to non-rinsing, polymerizable monomers to which one or more carboxylic or phosphate acid groups are grafted. Studies have proven that self-etch systems produce bond-strength values similar to total-etch systems to both dentin and enamel.^{2,10}

The glass-ionomer based adhesive (Fuji Bond LC) was introduced in 1995 and is essentially a diluted version of the restorative resin-modified glass-ionomer cement Fuji II LC.¹¹ Some recent research reports have demonstrated the favorable and somewhat unique characteristics of the adhesive, which were reported to have a fairly high tensile and shear bond strength and, according to a clinical report, were highly successful in retaining resin composite in non-undercut cervical cavities for a minimum of five years.¹²⁻¹³

However, to date, no study has evaluated the bonding ability of these newer adhesives for GIC or resin composite. The other advantage of these systems would be in their feasibility to be employed over unset GIC, as there is no need to rinse the GIC prior to application of

the bonding agent. Moreover, this modified protocol would not only prevent moisture contamination or desiccation of the underlying GIC, but it could also save precious chairside clinical time.

Hence, the aim of the current study was to evaluate the bonding ability of glass-ionomer cement with resin composite using self-etching primer and GIC-based bonding agents in comparison with total-etch adhesive. The other objective was to evaluate the bonding ability of these two bonding agents over set GIC in comparison with unset GIC.

In the current study, two new bonding techniques employing self-etching primer (Unifil Bond) and glass-ionomer based adhesive (Fuji Bond LC) were tried for bonding composite to glass-ionomer cement and the shear bond strength values were analyzed.

METHODS AND MATERIALS

One hundred samples were prepared and divided into five groups of 20 samples each. A split Teflon mold (6 mm in diameter, 9 mm in height) was used to prepare glass ionomer cylinders (Fuji II) 6 mm in diameter and 6 mm in height. Composite material (Solitare) was added to this instrumented surface of GIC to a height of 3 mm in increments following application of the appropriate bonding agent (Figure 1). The GIC surface was not finished to a glass-smooth surface to mimic the clinical scenario. Table 1 shows the materials used in the current study.

Group A (Total-etch bonding agent) (Adper Singlebond 2 Total Etch Bonding Agent, 3M ESPE Inc, St Paul, MN, USA).

Glass ionomer samples were prepared. An initial set of glass ionomers was confirmed with a sharp explorer after waiting seven minutes. The surface was treated with 37% phosphoric acid for 15 seconds and then rinsed. The bonding agent was applied and light cured. The composite material was then added in increments to a height of 3 mm and each increment was light cured (Elipar Highlight, ESPE, Germany) for 40 seconds.

Group B (Self-etch primer before initial set of GICs) (Unifil Bond self-etch primer, GC Corporation, Tokyo, Japan).

Glass ionomer samples were prepared. Self-etch primer was applied before the initial set of GICs. Air drying was done after 20 seconds; self-etch bonding agent was applied and light cured. Composite material was then added in increments to a height of 3 mm and light cured for 40 seconds.

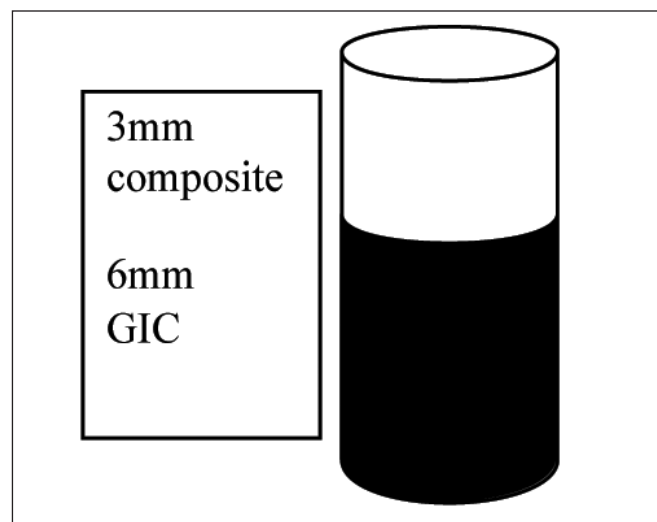


Figure 1. Schematic representation of samples.

Group C (Self-etch primer after initial set of GICs) (Unifil Bond self-etch primer, GC Corporation).

Glass ionomer samples were prepared. Self-etch primer was applied after the initial set of GICs was confirmed with a sharp explorer. Air-drying was done after 20 seconds; self-etch bonding agent was applied and light cured. Composite material was then added in increments to a height of 3 mm and each increment was light-cured for 40 seconds.

Group D: (Glass-ionomer based adhesive before initial set of GIC) (FujiBond LC, GC Corporation).

Glass ionomer samples were prepared. GIC-based adhesive was applied before the initial set of GICs and light cured. Composite material was then added in increments to a height of 3 mm and light cured for 40 seconds.

Group E: (Glass-ionomer based adhesive after initial set of GICs).

Glass ionomer samples were prepared. GIC-based adhesive was applied after the initial set of GICs were confirmed with a sharp explorer and light cured. Composite material was then added in increments to a height of 3 mm and light cured for 40 seconds.

Table 1: Materials Used in This Study

Material	Manufacturer
Fuji II Glass ionomer restorative	GC Corporation, Tokyo, Japan
Solare posterior composite restorative	GC Corporation, Tokyo, Japan
Adper Singlebond 2 total etch bonding agent	3M ESPE, St Paul, MN, USA
Unifil Bond self-etch primer	GC Corporation, Tokyo, Japan
Fuji Bond LC, Glass ionomer-based adhesive	GC Corporation, Tokyo, Japan

Table 2: Mean Shear Bond Strength in Study Groups (n=20), (p<0.05)					
Groups	Group A (Total Etch Adhesive)	Group B (Self-etch Primer)	Group C	Group D (GIC-based Adhesive)	Group E
SBS in Mpa ± S.D	4.001 ^b ± 0.12	4.50 ^a ± 0.09	3.08 ^c ± 0.19	3.75 ^b ± 0.12	4.49 ^a ± 0.13
Failure mode	5A, 8M, 7C	2A, 4M, 14C	13A, 5M, 2C	8A, 7M, 5C	3A, 5M, 12C
<i>Means with the same manuscript are not statistically different at p<0.05</i> <i>A-Adhesive failure, M-mixed failure, C-cohesive failure.</i>					

The samples were removed from the mold and mounted in a square metal jig (1 inch x 1 inch) filled with auto cure acrylic resin. The samples were then placed in 100% humidity at room temperature for 48 hours. The shear bond strength was determined using the Universal Testing Machine (Instron 8500, Instron Corporation, Norwood, MA, USA) at a crosshead speed of 1 mm/minute utilizing a device constructed to direct the shearing force on the glass-ionomer composite interface.

RESULTS

The mean shear bond strength and standard deviation were computed and analyzed by ANOVA (one-way analysis of variance) and Tukey's test at a significance level of 0.05. The mean shear bond strength and standard deviation are shown in Table 2. One-way analysis with ANOVA revealed significant differences in bond strength values among the different groups (p<0.001).

Group B (self-etch primer was applied before the initial set of GICs) and Group E (Fuji Bond LC was applied after the initial set of GICs) showed significantly higher bond strength than Group A (p<0.05). Group D (Fuji Bond LC was applied before the initial set of GICs) showed no significant difference in bond strength from Group A. Group C (self-etch primer applied after the initial set of GICs) showed the least bond strength values.

DISCUSSION

Recently, Knight and others¹⁴ proved that the co-cured resin-modified glass ionomer (RMGIC) bonding system (that is, sequential layering of GIC, RMGIC and resin composite prior to photo-polymerization and before the initial set of GICs) eliminates several placement steps and produces a significantly strong chemical bond between the GIC and resin composite compared to the etch and rinse technique. These authors also proposed that GIC bonding agent and resin composite may be co-cured to GIC either before or after the initial set has occurred. They also reported that bonding resin composite to GIC with RMGIC bond either before or after the initial setting of the GIC produced a bond strength beyond the cohesive strength of GICs.

However, no study to date has evaluated bonding between the GIC and composite using self-etch

primers or glass-ionomer based adhesive. Since both of these systems do not require the rinsing step, the bonding of composite to unset GIC was possible and, hence, was also evaluated in the current study.

The glass-ionomer surfaces were left uninstrumented in all the groups and not finished to a glass-smooth surface, because resin composite will not bond to a glass-smooth glass ionomer surface;⁵ moreover, this will also mimic the actual clinical scenario. Glass ionomers need somewhat erratic setting times, and to rely entirely on timing as an indication of a complete set may not be appropriate, hence, in the current study, the initial set was verified with a sharp explorer in accordance with the previous study by Magnum and others.⁵

In the etch and rinse group, the samples exhibited bond strength values that were comparable to values in previous studies,^{5,14} and bonding between the GIC and composite is purely micromechanical in nature.⁵ Resin composite will not bond to an unetched or glass-smooth glass ionomer surface.⁵ If the surface of the glass ionomer has been disturbed by instrumentation during placement, there will be a significant increase in bond strength.⁵ Also, if the GIC is etched after 24 hours of maturation, improvement in bond strength was reported.¹⁵ However this procedure requires an additional clinical visit.

In Group D, the GIC-based adhesive was placed immediately before the initial setting of the GIC and, in Group E, it was placed after the initial setting of the GIC. The bond strength values of the latter group were statistically superior to the unset GIC group (Group D) and the Total-etch group (Group A). These results are in contrast to the study by Knight and others, who proved the co-cure technique over unset GIC gave superior results. The superior performance of GIC-based adhesive over set GIC could be attributed to chemical bonding between the composites and resin modified glass-ionomers, which has been proven by previous reports.¹² This could be the reason for the higher number of cohesive failures in this group.

However, in the self-etch primer groups, the samples wherein the SEP was applied over the unset GIC (Group B) performed statistically better than the samples wherein the SEP was applied after initial setting

of the GIC (Group C). This group was statistically superior to the total-etch group and comparable to the GIC adhesive group placed over set GIC (Group E). Yoshida and others¹⁶ have proven that carboxylic acid monomers present in self-etch primers have a chemical bonding potential to calcium of residual hydroxyapatite of dentin. Hence, the authors of the current study hypothesize that carboxylic monomers in self-etch primers could have chemically bonded to calcium in unset GIC and, hence, a chemical union could be one possible reason for the higher bond strength. Also, most of the samples failed cohesively in this group.

CONCLUSIONS

In conclusion, the current study provides clinicians with two alternative techniques for laminate restorations in lieu of employing the traditional total-etch system. A clinician can thus employ a glass-ionomer adhesive system after the initial set of GICs or the clinician can use a self-etch primer over unset GIC. Clinically, the latter technique would be more useful, as it not only does away with the etch and rinse procedure, but it also saves valuable clinical time, as it can be employed immediately after placement of GIC in the cavity.

Further studies are needed to understand the mechanism of bonding between the GIC and composites bonded with different adhesive systems.

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