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Laboratory Research

Repair Bond Strength of High-viscosity Glass-ionomer Cements Using Resin Composite Bonded with Light- and Self-cured Adhesive Systems

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Clinical Relevance

High-viscosity glass-ionomer cements (HVGICs) used with atraumatic restorative treatment can be repaired with light- or self-cured adhesive systems; however, the repair bond strength of two-step, self-etching and one-step adhesives in the light-cure mode surpass one-step self-cure adhesives. Working on a feasible self-cure approach in the absence of such in rural areas as well as in war zones is of prime importance.

SUMMARY

Objectives: Despite the success rate of high-viscosity glass-ionomer cements (HVGICs) used in atraumatic restorative treatment (ART) restorations, partial or bulk fracture of the proximal portion has been recorded to be one of the main causes of proximal restoration failures. Repair of these restorative materials requires a practical solution, especially in cases where there is a lack of electricity. Thus, the purpose of this study was to evaluate the repair microshear bond strength (µSBS) of three HVGICs using a resin composite in association with adhesive systems having different curing modes (ie, light- vs self-curing mode).

Methods and Materials: A total of 105 discs (12 mm in diameter and 2 mm thick) of three HVGICs: GC Fuji IX GP Fast (GC Corporation, Tokyo, Japan); Fuji IX GP glass-ionomer cement containing chlorhexidine (GC Corporation, Tokyo, Japan); and ChemFil Rock zinc-reinforced HVGIC (Dentsply De-Trey GmbH, Konstanz, Germany) were prepared. Each specimen was divided into three horizontal sections, according to the tested adhesive system or curing mode: Clearfil SE Bond 2 (two-step, self-etch adhesive); (Kuraray Noritake Dental Inc., Tokyo, Japan) in light-cure mode; Clearfil Universal Bond (one-step, self-etch

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adhesive); (Kuraray Noritake Dental Inc., Tokyo, Japan) in light-cure mode; or Clearfil Universal Bond (one-step, self-etch adhesive); (Kuraray Noritake Dental Inc., Tokyo, Japan) in self-cure mode, mixing it with Clearfil DC Activator (Kuraray Noritake Dental Inc., Tokyo, Japan). A resin composite microcylinder was bonded to each horizontal section of each specimen using starch tubes. The bonded discs were stored in artificial saliva at 37°C for 24 hours. A μSBS test was conducted using a universal testing machine, while failure modes were determined using scanning electron microscopy. Data were statistically analyzed using two-way analysis of variance (ANOVA), one-way ANOVA, and Bonferroni post hoc tests (α=0.05).

Results: Two-way ANOVA revealed a statistically significant effect for the adhesive systems (p<0.01) and not for the HVGICs (p=0.05) nor their interactions (p=0.99). When using Clearfil SE Bond 2 and Clearfil Universal in a light-cure mode, significantly higher μSBS values were found when compared with Clearfil Universal in a self-cure mode.

Conclusions: The three tested HVGICs can be successfully repaired using two-step or one-step self-etch adhesive systems. The one-step self-etch adhesive system in light-cure mode is preferred when compared with the self-cure mode.

INTRODUCTION

Minimal tooth preparation and the application of adhesive therapeutic restorations are among the targets in minimal-intervention dentistry. The atraumatic restorative treatment (ART) approach fulfills these goals where the carious tooth is prepared using special hand instruments and high-viscosity glass-ionomer cements (HVGICs) are used. Underserved communities that lack electricity can also benefit from this approach when using the hand-mixed version of HVGICs because the need for an amalgamator to mix the activated capsules is removed. Also, a light curing unit is not required in contrast with many resin-modified glass-ionomer restorative materials. For primary teeth, a 93% success rate after two years has been recorded for single-surface ART restorations[1] and a 62% success rate was found for the compound or complex proximal restorations.[2]

When used in permanent teeth, ART recorded a 97% and 85% success rate for single-surface restorations after two and three years of clinical service, respectively; and a 95% and 85% success rate for proximal restorations after one and two years of clinical service, respectively.[1,3,4] Partial or bulk fracture of the proximal part of the restoration was reported to be one of the main causes of failure of proximal restorations.[5]

Marginal fracture of ART restorations can occur after a short time of clinical service, even within 24 hours, due to improper isthmus carving (especially if the restoration was placed by a less experienced operator), the presence of an unobserved plunger cusp, the induction of a crack during the removal of the proximal band, or inadvertent biting on a hard object (particularly within the first 24 hours of clinical service). Additionally, ART proximal restorations can fracture during clinical use, since the strength of the glass ionomer cement (GIC) materials (including HVGICs) cannot compete with the strength of direct resin composite materials.[6-8]

Repair, rather than replacement, of defective restorations is more conservative and cost effective. The immediate bonding of GICs to resin composite was reported to be acceptable.[9] A study was recently performed to evaluate the bonding ability of aged HVGIC using resin composite bonded using etch-and-rinse and self-etch adhesives.[10]

Two complications that may be encountered during the repair of defective HVGICs by direct resin composite is (1) the lack of electricity to cure the resin material, or (2) to have a fractured ditch deep enough to cause concern over the depth of cure with the light curing unit. In these cases, the use of adhesive systems and resin materials with a self-curing mode could be a solution.

To date, there are no studies regarding the repair potential of the different types of HVGICs used for the ART approach in conjunction with resin composite that is bonded using the universal one-step adhesive system in either the light-cure or self-cure mode.

The null hypotheses of the current study were: (1) there is no difference in the repair μSBS among the different HVGICs, and (2) there is no difference between the different adhesive systems/curing modes on the repair μSBS values of the tested HVGICs.

METHODS AND MATERIALS

Materials used in this study, and their batch numbers, manufacturers, and compositions are listed in Table 1.

Specimen Preparation

A stainless-steel flat washer, 20 mm in diameter and 2-mm thick, was used as a mould. The mould provided

Table 1: *Tested Material Names, Batch Numbers, Manufacturers, and Chemical Compositions*

Material/Batch No.	Manufacturer	Composition
GC Fuji IX GP Fast (radiopaque posterior glass-ionomer restorative cement in capsules; #0804141)	GC Corporation, Tokyo, Japan	Alumino-fluoro-silicate glass, polyacrylic acid, distilled water, polybasic carboxylic acid.
Fuji IX GP containing chlorhexidine HVGIC (radiopaque posterior glass-ionomer trial restorative cement in powder/liquid)	GC Corporation, Tokyo, Japan	Powder: Alumino-fluoro-silicate glass to which 1% chlorhexidine diacetate was incorporated. Liquid: polyacrylic acid, distilled water, polybasic carboxylic acid.
ChemFil Rock (advanced glass-ionomer restorative material in capsules; #K79200030-03)	Dentsply De-Trey GmbH, Konstanz, Germany	Calcium-aluminium-zinc-fluoro-phosphor-silicate glass, polycarboxylic acid, iron oxide pigments, titanium dioxide pigments, tartaric acid, water.
Dentin conditioner (#280739GC)	GC Corporation, Tokyo, Japan	20% polyacrylic acid, 3% aluminum chloride hexahydrate component.
Clearfil SE Bond 2 (two-step, self-etch adhesive system; dental universal self-etch adhesive; primer: #3282KA; bond: #3281KA)	Kuraray Noritake Dental Inc., Tokyo, Japan	Primer: MDP, HEMA, hydrophilic dimethacrylate, dl-camphorquinone, N,N-diethanol-ptoluidine, water. Bond: MDP, Bis-GMA, HEMA, hydrophobic dimethacrylate, dlcamphorquinone, N,N-diethanol-p-toluidine, silanated colloidal silica.
Clearfil Universal Bond (single component adhesive; #6B0016)	Kuraray Noritake Dental Inc., Tokyo, Japan	Bis-GMA, HEMA, ethanol, 10-MDP, hydrophilic aliphatic dimethacrylate, colloidal silica, dl-camphorquinone, silane coupling agent, accelerators, initiators, water.
Clearfil DC Activator (#3250KA)	Kuraray Noritake Dental Inc., Tokyo, Japan	Activator, ethanol, catalysts, accelerators.
Clearfil DC Core Plus Dual-cure, radiopaque two-component core build-up material (#2942KA)	Kuraray Noritake Products Corporation, Tokyo, Japan	Paste: Bis-GMA, hydrophilic aliphatic dimethacrylate, hydrophobic aliphatic dimethacrylate,hydrophobic aromatic dimethacrylate, silanized barium glass filler, silanized colloidal silica, colloidal silica, chemical-initiator, photo-initiator, pigments. Paste: TEGDMA, hydrophilic aliphatic dimethacrylate, hydrophobic aromatic dimethacrylate, silanized barium glass filler, silanized colloidal silica, aluminum oxide filler, photo-accelerator, chemical-accelerator.

Abbreviations: Bis-GMA, bis-phenol A diglycidylmethacrylate; HEMA, 2-hydroxyethyl methacrylate; MDP, 10-methacryloyloxydecyl dihydrogen phosphate; TEGDMA, triethylene-glycol dimethacrylate.

an internal hole with a 12 mm diameter to allow for the packing of the tested material. A total of 105 discs of the three tested HVGICs: Fuji IX GP Fast capsules (GC Corporation, Tokyo, Japan), Fuji IX GP glass-ionomer cement containing chlorhexidine (GC corporation, Tokyo, Japan), and ChemFil Rock zinc-reinforced capsules (Dentsply De-Trey GmbH, Konstanz, Germany) were prepared. The mould was placed on a celluloid strip and a dry glass slab. Then, each tested HVGIC was mixed according to the manufacturer's instructions and packed into the internal hole of the mould. Another glass slide was placed over the packed disc, with pressure to compact the material until it was completely set.

Specimens were left to set at room temperature (23°C) and at 100% humidity for 20 minutes. After removal of the glass slab, each HVGIC disc was checked for any pitting or defects to be discarded. Vaseline was applied and the discs were stored at 100% humidity in an incubator with a 37°C adjusted temperature for 24 hours.

Grouping of the Specimen

Two equidistance horizontal notches were made to divide the HVGIC disc into three horizontal sections. Each section received one of the tested repair adhesive systems: light-cured Clearfil SE Bond 2 (two-step, self-etch adhesive; Kuraray Noritake Dental Inc., Okayama, Japan) or Clearfil Universal Bond (one-step, self-etch adhesive; Kuraray Noritake Dental Inc., Okayama, Japan) in light-cure mode or Clearfil Universal Bond (one-step, self-etch adhesive) in self-cure mode, with Clearfil DC Activator (Kuraray Noritake Dental Inc., Okayama, Japan). A dual-cured Clearfil DC Core Plus (Kuraray Noritake Dental Inc., Okayama, Japan) with an automix delivery system was used as the repair material. A build-up microcylinder was bonded with each adhesive system on each HVGIC disc, providing 315 microcylinders (n=35 per group).

Restorative Procedures

All HVGIC discs were wet-ground flat using 600-grit silicon carbide paper to obtain a smooth, matte surface, and then etched using Scotchbond Etchant gel (3M ESPE, St Paul, Minnesota, USA) for 15 seconds, rinsed with oil-free water from an air/water syringe for 15 seconds, and blotted dry using gauze to prevent desiccation of the cement.

Starch tubes (pasta ZARA, Brescia, Italy) with a 0.96-mm internal diameter were cut to a height of 1 mm to be used to build-up the Clearfil DC Core Plus microcylinders.[11] The tip of the automix syringe of the Clearfil DC Core Plus was used to inject the material into the starch tubes. After the application of each adhesive system (according to the manufacturer's instructions), a filled starch tube was randomly placed onto each horizontal section and light cured for 20 seconds using the LED Curing Light (GC America Inc., Alsip, Illinois, USA), with a wavelength range of 440-490 nm and an energy output of 650 mW/cm^2. The light intensity of the curing unit was checked using an LED radiometer (Kerr Dental Specialties, Orange, California, USA) at the beginning of the study and every week during the study period.

For the first horizontal section, Clearfil Bond 2 Primer was applied for 20 seconds and dried with a mild air flow for 5 seconds. Clearfil Bond 2 Bond was applied and gently air-thinned using oil-free air for 2 seconds, and then light cured for 10 seconds. For the middle horizontal section, Clearfil Universal Bond was rubbed for 10 seconds, gently air-dried using oil-free air for 5 seconds, and light cured for 10 seconds.

One drop of Clearfil Universal Bond was mixed with one drop of Clearfil DC Activator, and the mixed adhesive was applied to the third horizontal section of each HVGIC disc. The adhesive was rubbed for 10 seconds and dried using mild air flow for 5 seconds. A Clearfil DC Core Plus build-up-filled starch tube was placed onto the third section of the disc. This section, that received the self-cure mode repair system, was allowed to dark-cure for 20 minutes. Afterward, all bonded HVGIC discs were immersed in artificial saliva for 4 hours at 37°C to soften the starch tubes. The softened starch tubes were carefully removed using a #11 sharp lancet (Wuxi Xinda Medical Device Co., Jiangsu, China), leaving the resin composite microcylinders bonded to the HVGIC discs. Resin composite microcylinders were checked using a magnifying lens (Bausch and Lomb, Co. Rochester, New York, USA) at 6x magnification to detect interfacial gaps, bubble inclusions, or other defects, which were excluded. Bonded discs were stored in artificial saliva in a 37°C incubator for 24 hours.

Microshear Bond Strength Testing

To avoid bias, the bonded discs were coded by a person other than the authors, thus blinding the testing and statistical analysis.[12] Each bonded HVGIC disc was secured in the lower part of a specially designed attachment jig to hold the specimens to the testing machine.[13] The attachment jig was in turn screwed into the lower fixed and the upper movable compartments of the testing machine (Model LRX-plus; Lloyd Instruments Ltd., Ferham, UK), with a load cell of 5 kN. A wire loop prepared from a 180 µm orthodontic stainless-steel ligature wire (G&H Orthodontics, Franklin, Indiana, USA) was wrapped around the bonded microcylinder as close as possible to its base and touching the HVGIC surface. A tensile load was applied via the testing machine at a crosshead speed of 0.5 mm/minute. Data were recorded using computer software (Nexygen-MT; Lloyd Instruments, UK). The calculation of the μSBS value was done by dividing the load at failure by the bonding area to express the bond strength in MPa.

Statistical Analysis

Data were statistically presented in terms of mean ± standard deviation (SD). In the present study, the repair bond strengths of the different adhesives were considered as the dependent variables, while the HVGICs were the independent variables. Normal distribution of the data was verified using the Kolmogorov-Smirnov test. A two-way ANOVA test was performed to determine the effect of the adhesive systems and the HVGICs on the repair bond strength. Two-way ANOVA was also used to detect any significant interactions between these two variables. One-way ANOVA was used to detect any significant differences among the μSBS repair values of each tested adhesive system applied with the different HVGICs and among the μSBS repair values of each tested HVGIC repaired with the different adhesive systems. Bonferroni test was used for pairwise comparisons. Statistical calculations were done using the computer program SPSS for Microsoft Windows version 15 (Statistical Package for the Social Science; SPSS Inc., Chicago, Illinois, USA).

Mode of Failure

After measuring the bond strength, each HVGIC disc was examined using an environmental scanning electron microscope (Quanta 200; FEI Company, Philips, Netherlands) at 25 Kv to determine the failure modes of the detached microcylinders. The failure mode was categorized as follows:

Type I: Adhesive failure at the HVGIC interface.
Type II: Cohesive failure in the adhesive layer.
Type III: Cohesive failure in HVGIC.
Type IV: Mixed failure (involving both adhesive and cohesive failures).

Representative photomicrographs for the failure modes were captured at various magnifications.

RESULTS

The mean and SD for each experimental group are listed in Table 2. Two-way ANOVA revealed a statistically significant effect for the adhesive systems ($p<0.01$) but not for the HVGICs ($p=0.05$) and their interactions ($p=0.99$). Based on this, the first null hypothesis failed to be rejected, while the second null hypothesis was rejected.

For each HVGIC (GC Fuji IX GP Fast, Fuji IX GP containing chlorhexidine, and ChemFil Rock), one-way ANOVA revealed a statistically significant difference among the three adhesive systems ($p=0.02$). as shown in Table 2. The light-cured modes of Clearfil SE Bond 2 and Clearfil Universal presented significantly higher μSBS values when compared to Clearfil Universal in self-cure mode (Table 2).

Table 2: *Repair Microshear Bond Strength Values (Mean [SD]) in MPa of the Tested Adhesives to the Different High-viscosity Glass-ionomer Cements*

HVGICs	Adhesive Systems			
	Clearfil SE Bond 2	Clearfil Universal Bond light-cure mode	Clearfil Universal Bond self-cure mode	*p*-value
GC Fuji IX GP Fast	23.45 (7.4)aA [Ptf/tnt=0/35]	21.06 (6.7)aA [Ptf/tnt=0/35]	15.75 (5.8)aB [Ptf/tnt=3/35]	0.025
Fuji IX GP- CHX	27.66 (6.5)bA [Ptf/tnt=0/35]	25.69 (8.5)aA [Ptf/tnt=0/35]	19.29 (8.0)aB [Ptf/tnt=3/35]	0.025
ChemFil Rock	25.96 (6.3)aA [Ptf/tnt=0/35]	24.47 (7.3)aA [Ptf/tnt=0/35]	18.48 (6.8)aB [Ptf/tnt=4/35]	0.028
p-value	0.32	0.31	0.40	

Different uppercase letters denote significant differences within rows. Different lowercase letters denote significant differences within a column.

Abbreviations: CHX, chlorhexidine; HVGICs, high-viscosity glass-ionomer cements; Ptf, pretest failure; SD, standard deviation; tnt, total number of tested specimens.

Regarding the failure modes, when GC Fuji IX GP Fast, Fuji IX GP containing chlorhexidine, and ChemFil Rock HVGICs were bonded using the light-cured Clearfil SE Bond 2 and Clearfil Universal, they presented predominately mixed failures followed by cohesive failures in the adhesive layer. Alternatively, Clearfil Universal in self-cure mode mainly presented cohesive failures in the adhesive layer. Figure 1 depicts the percentages of the recorded failure modes. Representative scanning electron micrographs for some failure modes of the tested HVGIC specimens are presented in Figure 2.

DISCUSSION

Previous studies have mainly focused on the repairability of the resin-modified GICs.[14-16] Additionally, the bond strength of earlier versions of conventional GICs to resin composite has been investigated.[17-21] Nevertheless, no published study has considered the reparability of the recent types of HVGICs, which are used as final restorations in ART treatment, and using resin composite with different curing modes.

Based on the results of this current study, all tested HVGICs could successfully be repaired. Researchers showed that successful bonding to GIC is based on two components: inherent microporosities of the material and the use of an interfacial bonding agent.[17]

When evaluating the structure, the relatively large glass particles embedded in the HVGIC matrix provides porosities, which could act as undercuts capable of retaining additional material that can penetrate within those porosities. The relatively higher, but not significant, repair bond strength of all tested adhesive systems to chlorhexidine containing HVGIC could validate this hypothesis. As it is, a hand-mixed powder and liquid product, chlorhexidine containing HVGIC could present an increase in microporosities when compared with the other tested capsulated HVGICs, which could allow for an increase in the microretention of the intermediate materials.[22] Meanwhile, the minor difference in porosity between restorative cements mixed with both methods[23] might explain the nonsignificant differences in the results recorded among the tested HVGICs in the present study.

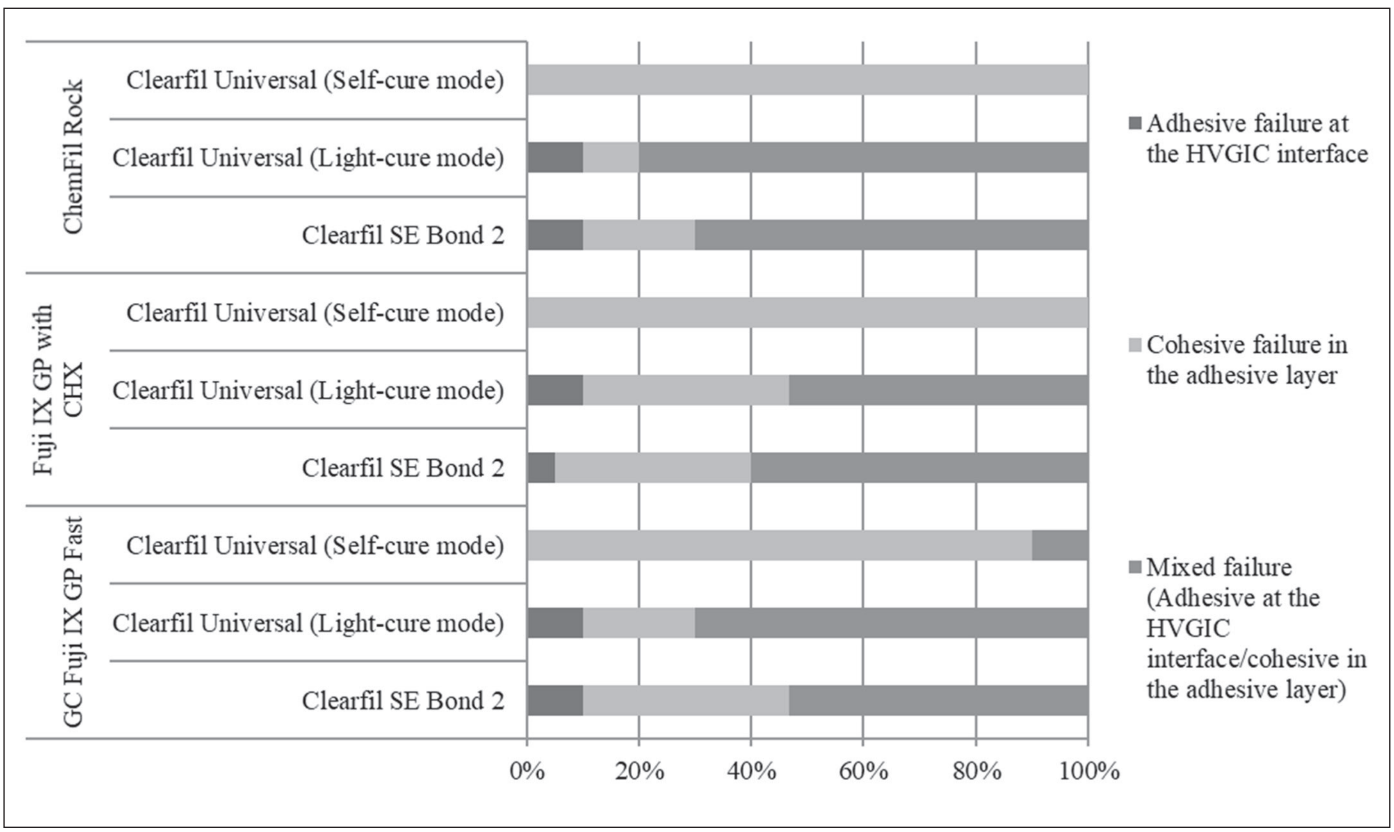

Figure 1. *The percentages of the recorded modes of failure in the tested groups.*

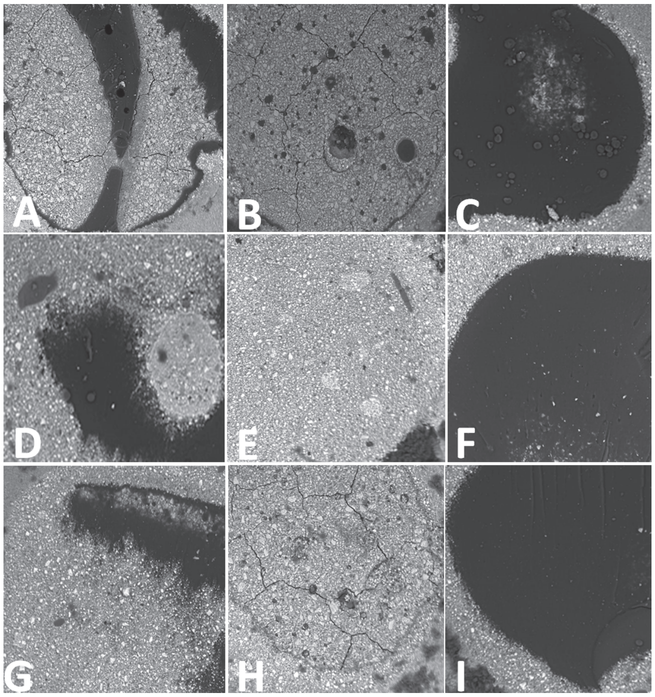

Figure 2. *SEM photomicrographs showing the failure modes of GC Fuji IX GP Fast (A–C), Fuji IX GP containing chlorhexidine (D–F), and ChemFil Rock (G–I). (A, D, G): Represent mixed failure; (adhesive failure at the HVGIC interface and cohesive failure in the adhesive layer). (B, E, H): Represent adhesive mode of failure at the HVGIC interface. (C, F, I): Correspond to the cohesive mode of failure in the adhesive layer. Abbreviation: SEM, scanning electron microscope.*

Etching prior to performing a repair is a point of controversy. Some authors found that etching the material had no significant effect on the bond strength,[20,21] with some authors proving that it weakened the cohesive strength of the material, [24] and others demonstrating that it improved the bond strength.[19,25,26]

Despite the differences in the experimental methods, those studies concluded that etching could be a practical step provided it was done after complete setting of the material (24 hours), utilized 37% phosphoric acid concentration for 15 seconds, and was followed by 15 seconds of rinsing.[9] Etching of the material to be repaired is clinically recommended, as it acts as a microscopic cleaning procedure and helps to expose fresh glass particles, which could enhance the chemical interaction with some self-etch adhesives. Moreover, the evaluated HVGICs proved to have high physicomechanical properties [27,28] that could allow them to withstand the minor effect of etching.

Reliable bonding between GICs and resin composites should always be done in conjunction with an effective intermediate bonding agent.[17] Self-etch adhesive systems are user friendly, less technique sensitive, and require less clinical application time; therefore, they are frequently used to achieve the equivalent bond strength to etch-and-rinse adhesives. To date, one study discussed the bond strength of light-cured self-etch adhesive systems to one HVGIC.[10]

It has been suggested that some self-etch adhesives are able to form a chemical bond to the calcium content of the tooth structure; therefore, they also could chemically bond to the calcium and strontium present in the HVGICs.[10] This could explain the high bond strength of the two-step Clearfil SE Bond 2 or one-step Clearfil Universal adhesive, as both contain 10-methacryloyloxydecyl dihydrogen phosphate, which can bond to the calcium and strontium contents of HVGICs.[10]

Nonetheless, it should be noted that universal adhesives have an increased hydrophilicity and high acidic monomer concentration. Water is required to ionize the acidic monomer, dissolve the smear layer, and demineralize the substrate. High acidic monomer concentrations could lead to water sorption and osmotic blistering, resulting in a decrease of the marginal integrity of the adhesive and creating a weakened adhesive area. The repair bond durability of HVGICs with universal adhesives is still under investigation.

This present study showed a significantly low bond strength of the Clearfil Universal adhesive in self-cure mode when compared with the light-cured approach. Although no published study investigated the performance of the universal adhesive in the light- versus self-cure modes bonded to HVGIC, the results of Foxton and others reported that light exposure of the dual-cured adhesive improved its bonding to root dentin.[29]

Previous studies have reported an incompatibility problem between the residual acidic monomers present at the oxygen-inhibited layer of the simplified adhesive, which react with the initiator component (aromatic tertiary amine) in the dual-cured composite core; this reaction hinders polymerization of the material. The use of a self-cured activator has been suggested to eliminate this incompatibility. The latter has a sodium salt of aryl sulfinic acid, which reacts with the acidic monomers to produce phenyl- or benzene-sulfonyl free radicals to initiate the self-cured composite polymerization. However, the use of a self-cured activator did not achieve a comparable result to the use of the universal adhesive in either the light-cured or dual-cured modes.[30] It is important to know that Clearfil DC Core Plus, which was used in the present study, has a "slow" setting, self-cure mechanism. This is due to the reduction in its camphorquinone content, which minimizes its sensitivity to ambient light. Further research is required to determine whether the slow setting mechanism inhibits polymerization due to the diffusion of the acidic monomer from the adhesive system to the resin composite.[30, 31]

The results of this current study add to the clinical knowledge of the repair of ART restorations. The idea of using a dual-cured resin composite core build-up to overcome some of the limitations of a light-cured resin composite could be of value. The dual-cured resin composite provides proper handling characteristics, extended working time, and it eliminates the depth-of-cure problem faced in critically inaccessible areas. Manufacturers have claimed that these materials will satisfactorily cure in 5 to 7 minutes without light exposure. It has been suggested that a 20- to 60-second delay in light-curing dual-cured core build-up materials could minimize the interference of the self-curing mechanism of these materials, allowing initial conversion and decreasing the polymerization shrinkage stresses of the materials.[32] However, this delay might allow for moisture contamination or added time during clinical procedures that might complicate the case. Further research on the curing performance of dual-cured resin composite is recommended.

Analysis of the mode of failure as a complementary step for bond strength testing was performed in the present study. All HVGICs bonded with the light-cured Clearfil SE Bond 2 and Clearfil Universal light-cured mode specimens showed a predominantly mixed type of failure. On the other hand, the specimens of Clearfil Universal in self-cure mode predominantly had cohesive failures in the adhesive layer, which is a concern regarding the quality of bonding. These results were in agreement with the bond strength results.

Finally, the present study demonstrates that the use of a dual-cure resin composite material in combination with light-cured, self-etch adhesive systems could be a successful repair approach for defective or undercontoured HVGICs used in ART restorations. The use of the self-cure mode in repairing defective restorations requires further study to enhance its bond strength values and quality of bonding. ART is a minimally invasive approach to dentistry, representing an optimum treatment option for geriatric patients, patients with special needs or rare diseases, and patients with dental anxiety. The use of ART can be extended to various restorative techniques, such as the delayed sandwich technique and protective restorations. Moreover, working on self-cure approach to be feasible in the absence of eccentricity in rural areas as well as in war zones is of a prime request.

CONCLUSIONS

The three tested HVGICs could be successfully repaired using two-step/one-step self-etch adhesive systems. The one-step self-etch adhesive system in light-cure mode is preferred when compared with the self-cure mode.

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Conflict of Interest

The authors of this article certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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