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This study evaluated the effect of dentin surface treatment on shear bond strengths of two visible light activated glass ionomer restorative materials to dentin. Cylinders of Fuji II LC and VariGlass VLC were bonded to dentin surfaces that were untreated, treated with a 10% polyacrylic acid (GC Conditioner), or treated with a dentin bonding agent primer (Prisma Universal Bond 3 Primer). Specimens were thermo-cycled and tested in shear at 7 days. Data for each restorative material were subjected to one-way ANOVA and Tukey's procedure at the 0.05 probability level. For Fuji II LC, mean bond strength to Conditioner-treated dentin was significantly higher than mean bond strength to Primer-treated dentin and to untreated dentin. For VariGlass VLC, mean bond strength to Primer-treated dentin was significantly higher than mean bond strength to untreated dentin. Bond strengths to Primer-treated dentin and Conditioner-treated dentin were not significantly different.

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Dentin surface treatment and bond strength of glass ionomers

DAVID G. CHARLTON, DDS, MSD & CARL W. HAVEMAN, DDS, MS

Abstract: This study evaluated the effect of dentin surface treatment on shear bond strengths of two light-cured glass ionomer restorative materials to dentin. Cylinders of Fuji II LC and VariGlass VLC were bonded to dentin surfaces that were untreated, treated with a 10% polyacrylic acid (GC Conditioner), or treated with a dentin bonding agent primer (Prisma Universal Bond 3 Primer). Specimens were thermocycled and tested in shear at 7 days. Data for each restorative material were subjected to one-way ANOVA and Tukey's procedure at the 0.05 probability level. For Fuji II LC, mean bond strength to conditioner-treated dentin was significantly higher than mean bond strength to primer-treated dentin and to untreated dentin. For VariGlass VLC, mean bond strength to primer-treated dentin was significantly higher than mean bond strength to untreated dentin. Bond strengths to primer-treated dentin and conditioner-treated dentin were not significantly different. (*Am J Dent* 1994; 7: 47-49).

Clinical significance: Dentin treated with GC Conditioner or Prisma Universal Bond 3 Primer significantly increased the shear bond strength of Fuji II LC and VariGlass VLC, respectively.

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Introduction

Glass ionomer cements have become extremely popular in clinical dentistry since their introduction in the mid-1970s. They have been used as bases/liners,¹ luting agents,² core build-up materials,^{3,4} and even pit and fissure sealants.⁵ Although direct filling forms of the glass ionomer cements have been marketed for many years, only chemically set forms were available. Recently, light activated glass ionomer restorative materials were introduced to the market.

The manufacturers of light activated glass ionomer restorative materials differ in their recommendations regarding dentin treatment prior to bonding. In the instructions for the use of their products, the manufacturers of Fuji II LC^a recommend that a 10% polyacrylic acid solution (GC Conditioner^a) be applied prior to placing their product, while the makers of VariGlass VLC^b suggest that a dentin bonding agent primer (Prisma Universal Bond 3 Primer^b) be applied as a means of improving bond strength.

The purpose of this study was to evaluate the effect of dentin surface treatment on shear bond strength of light-cured glass ionomer restorative materials to dentin.

Materials and Methods

Ninety extracted, non-carious human molars stored in 10% formalin were used in the bond strength test. The occlusal surfaces of the teeth were ground on a water-cooled model trimming wheel to prepare flat dentin surfaces. The teeth were then mounted with autopolymerizing resin using cylindrical Teflon (polytetrafluoroethylene) molds so that the prepared dentin surfaces were flush with one end of the acrylic resin cylinders. After the resin had completely polymerized, the dentin surfaces were hand finished using 20 strokes each on wet 400 and 600 grit silicon carbide abrasive papers. After finishing, the teeth were examined at x8 using a stereomicroscope^c to ensure that all enamel

had been removed and were then stored in room temperature (23°C) distilled water. The teeth were randomly divided into six groups of 15 teeth and treated as follows:

Group 1. The dentin surfaces were dried with oil-free, compressed air. A split Teflon mold with an internal diameter of 5 mm was placed against the dentin surface and stabilized with an alignment tube. Fuji II LC was mixed according to manufacturer's instructions by mixing one level scoopful of powder with two drops of liquid. The mixed material was inserted into the mold in 1 mm increments using a placement syringe.^d Each increment was light activated by exposure for 20 seconds to a polymerization unit (Optilux 400^e). After polymerization of the final increment, the alignment tube and Teflon mold were removed and the specimen was placed in room temperature distilled water.

Group 2. The dentin surfaces were dried with oil-free, compressed air. GC Conditioner, a 10% polyacrylic acid solution, was applied to the dentin surfaces for 20 seconds with a scrubbing motion using a cotton-tipped applicator. The dentin surfaces were then rinsed with tap water for 10 seconds and dried with oil-free, compressed air. Cylinders of Fuji II LC were bonded to the dentin surfaces as described for Group 1.

Group 3. The dentin surfaces were dried with oil-free, compressed air. Prisma Universal Bond 3 Primer, a dentin bonding agent primer, was applied to the dentin surfaces and was allowed to remain undisturbed for 30 seconds. The primer was then gently dried with oil-free, compressed air for 10 seconds. Cylinders of Fuji II LC were bonded to the dentin surfaces as described for Group 1.

Groups 4, 5, and 6 were prepared in the same manner as were Groups 1, 2, and 3, respectively, except that VariGlass VLC was bonded to the dentin surfaces. The VariGlass VLC was prepared according to manufacturer's instructions by mixing one level scoopful of powder with two drops of liquid.

All of the specimens were stored for 72 hours in room

Table 1. Mean shear bond strength (MPa).

Dentin treatment	Restorative material	
	Fuji II LC	VariGlass VLC
GC Conditioner	9.9 (2.1)	5.7 (1.6)
Prisma Universal Bond 3 Primer	3.3 (2.5)	6.4 (1.3)
No treatment	1.4 (2.0)	4.6 (1.3)

N=15. Standard deviations given in parentheses. Vertical lines connect nonsignificant differences at the 0.05 probability level.

Table 2. Modes of failure.

Dentin treatment	Restorative material					
	Fuji II LC			VariGlass VLC		
	C	A	M	C	A	M
GC Conditioner	2	0	13	0	0	15
Prisma Universal Bond 3 Primer	0	6	9	2	0	13
No treatment	0	6	9	4	0	11

C=Cohesive failure within the restorative material and/or dentin.
A=Adhesive failure between the restorative material and dentin.
M=Combination of cohesive and adhesive failures. Numbers indicate the number of specimens exhibiting a particular type of failure.

temperature distilled water and then thermocycled for 500 cycles between 5°C and 55°C water baths. A dwell time of 40 seconds was used for each bath. The specimens were then stored in room temperature distilled water. After 7 days, the specimens were tested in shear using a steel ring attached to a testing machine (Tinius Olsen series 1000^f). The specimens were loaded to failure at a crosshead speed of 0.5 mm/min. The data were analyzed using two-way analysis of variance (ANOVA) and Tukey's procedure at the 0.05 level of significance.

After bond strength testing, the specimens were examined using a stereomicroscope at x8 to determine the mode of failure between the adhesive materials and dentin. Failures were recorded as adhesive (those occurring between the glass ionomer cement and dentin), cohesive (those occurring within the glass ionomer cement and/or dentin), or mixed (combination of adhesive and cohesive).

Results

The mean shear bond strengths for the six groups are presented in Table 1. Because analysis of the data using two-way ANOVA revealed a significant interaction term ($P<0.05$), the data for each of the two materials were analyzed with separate one-way ANOVA tests. For Fuji II LC, mean bond strength to conditioner-treated dentin was significantly higher than mean bond strengths to primer-treated dentin and to untreated dentin. For VariGlass VLC, mean bond strength to primer-treated dentin was significantly higher than mean bond strength to untreated dentin. Bond strengths to primer-treated dentin and conditioner-treated dentin were not significantly different.

The modes of failure for the specimens are presented in Table 2. For each group, the majority of failures were mixed, indicating a combination of adhesive and cohesive failures. For all of the purely cohesive failures, failure occurred within the restorative material and dentin or within

the restorative material alone; none of the cohesive failures occurred completely within dentin.

Discussion

The application of surface-altering solutions to dentin prior to bonding with glass ionomer cements has a long history.⁶⁻⁸ The purpose of applying these solutions has been to increase the strength of the bond formed between the dentin surface and cement. For chemically-cured glass ionomers, one of the first solutions used for this purpose was citric acid.⁹ Although 50% citric acid was commonly used as a dentin conditioning agent, it fell out of favor because it lacked biocompatibility, it opened dentin tubules,¹¹ and produced either no increase or a decrease in bond strength.¹¹⁻¹³ Polyacrylic acid in various concentrations has also been suggested as a dentin conditioner prior to placement of chemically set glass ionomer cement because Powis *et al*¹¹ believed that it increases wettability of the dentin surface and improves ion exchange with the cement. Although researchers have recommended its use in an attempt to maximize bond strength,¹¹ suggested concentrations and application times have varied. Berry *et al*¹⁴ used scanning electron microscopy to evaluate dentin surfaces treated with a number of conditioning solutions and concluded that a 5-second application of 40% polyacrylic acid produced the most ideal surface for bonding. However, Long *et al*¹⁵ found that a 30-second treatment with either 30% or 35% polyacrylic acid produced bond strengths that were significantly higher than those produced using 15%, 20%, 25%, and 40% solutions. Although differences in opinion remain concerning application times and concentrations for polyacrylic acid, researchers continue to recommend its use as a dentin pretreatment with chemically set glass ionomer products.¹⁶ Dentin surface treatment remained a topic for research as new, resin-containing glass ionomer products such as the visible light activated liners/bases were introduced to the market. Prati *et al*¹⁷ evaluated the effects of nine dentin surface treatments on the shear bond strength of Vitrabond[®] to human dentin. They found that although many of the treatments significantly altered the dentin as observed using scanning electron microscopy, only neutral and acidic oxalate solutions significantly increased the bond strength. This finding implies that glass ionomer products which contain resin may require dentin treatments that differ from those used with traditional glass ionomer cements.

It should not be surprising then that the dentin treatment used with the recently developed visible light activated glass ionomer restorative material VariGlass VLC differs from those recommended for use with chemically set glass ionomer forms. Because the liquid component of this product contains acrylic monomers, dentin treatment with dentin bonding primers rather than polyacrylic acid may be effective in maximizing bond strengths. Prisma Universal Bond 3 Primer (30% hydroxyethyl methacrylate, 6% phosphonated penta-acrylate ester in ethanol) and similar primers that contain hydrophilic monomers facilitate

Wetting of dentin and enhance bonding between dentin and resin-containing materials.¹⁸ It is surprising, however, that dentin treatment with polyacrylic acid is recommended by the manufacturer of Fuji II LC considering the fact that the liquid of Fuji II LC contains approximately 40% hydroxyethyl methacrylate (manufacturer's data).

This study noted that for Fuji II LC the strongest bond to dentin was formed when GC Conditioner was applied to the dentin immediately prior to bonding. Bond strengths to Prisma Universal Bond 3 primer-treated dentin and untreated dentin were significantly lower. For VariGlass VLC, however, the strongest bond was to primer-treated dentin. Although a weaker bond formed to conditioner-treated dentin, it was not significantly different. For both materials, the weakest bond was to untreated dentin. These differences may suggest a difference in composition between the two glass ionomer products or a dissimilarity in the way they wet or interact with the treated dentin surface. Future research should be directed toward evaluating the manner in which other dentin pretreatment solutions affect the bond strength of these glass ionomer restorative materials. Because of the results found with light activated glass ionomer liners/bases, oxalate solutions in particular may warrant evaluation as possible dentin pretreatment solutions.

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- a. GC America, Chicago, IL, USA.
- b. L.D. Caulk, Milford, DE, USA.
- c. Carl Zeiss, Thornwood, NY, USA.
- d. Centrix, Inc., Shelton, CT, USA.
- e. Demetron Research, Danbury, CT, USA.
- f. Tinius Olsen, Willow Grove, PA, USA.
- g. 3M Co., St. Paul, MN, USA.

The opinions expressed herein are those of the authors and do not necessarily reflect the opinions of the Department of Defense or the United States Air Force.

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CE Questions - Dentin surface treatment and bond strength of glass ionomers.

1. For Fuji II LC, stronger bond strengths were recorded with:

- A. Dentin treated with polyacrylic acid
- B. Dentin treated with a primer
- C. Not treated dentin
- D. No difference between treatment

2. For VariGlass VLC, stronger bond strengths were recorded with:

- A. Dentin treated with polyacrylic acid
- B. Dentin treated with a primer
- C. Not treated dentin
- D. No difference between treatment

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