

A comparison of a hybrid light-cured glass-ionomer base and liner vs. a light-cured resin tooth fragment attachment

Jeffrey A. Dean, DDS, MSD Anthony L. Minutillo, DDS, MSD B. Keith Moore, PhD

Abstract

Purpose: *The purpose of this study was to compare the dislodgement strengths and fracture types for reattached tooth fragments using a light-cured composite resin material, a hybrid light-cured glass ionomer base, and a hybrid light-cured glass ionomer liner.*

Methods: *Seventy-five bovine incisor teeth were fractured, randomly divided into three groups of equal number, and then luted back together with three different materials (Universal Bonding Agent/TPH Composite Resin; VariGlass VLC Base; and VariGlass VLC Liner: LD Caulk Div Dentsply Int Inc, Milford, DE). The reattached fragments were subjected to thermocycling with a 40°C differential and then were loaded until the force required to dislodge the fragment was reached.*

Results: *The mean dislodgement strengths were 36.8 (± 25.6) kg for the composite resin, 36.4 (± 26.7) kg for the glass ionomer base, and 31.4 (± 29.5) kg for the glass ionomer liner. Cohesive fractures occurred in 73% of the dislodgements.*

Conclusions: *There was no statistically significant difference demonstrated ($P < 0.05$) between the three groups in terms of both dislodgement strength and fracture type. (Pediatr Dent 20:1, 49–52, 1998)*

Trauma to the dentition from falls accounts for most dental injuries to young permanent teeth, while contact sports and automobile accidents cause significant dental injuries to both children and adolescents.^{1–3} Dental trauma has both a physical and psychological effect on a child by influencing both dental function and appearance. Restorations had not been accomplished with much overall success until the advent of acid-etch resins. However, success can be limited due to the lack of wear and stain resistance in resins. The shortcomings of resins have been addressed by a method in which the fragment is reattached to the fractured tooth with composite resin. A study by Dean et al.⁴ showed com-

parable strengths when fragments were meshed together and luted by resin, with or without mechanical tooth preparations. More recently, reports involving successful fragment reattachment with glass ionomer have appeared.⁵ Glass ionomer is recommended in many situations because of its dentin-bonding, fluoride-releasing, and decreased microleakage properties.⁶

Bond strengths of tooth fragments reattached by glass ionomer have yet to be reported. Because of the chemical bond formed by glass ionomers to tooth structure and the intimate meshing together of the tooth pieces, the fragment restoration with glass ionomer should be comparable in strength to that of composite resins. This study measures the forces required to cause separation of tooth fragments using either a hybrid light-cured glass ionomer or a light-cured composite resin. The nature of the failure at the fracture site was also determined (i.e., adhesive, cohesive, or mixed).

Methods

Fracture procedure

Two hundred previously unrestored and noncarious bovine incisors were selected for the study. Each tooth was embedded in a 1.5-in diameter cylinder of model plaster. A blunt chisel was placed at the tooth/plaster interface and a finger was placed on the lingual surface of the tooth for support. A hammer was used to strike the chisel to produce an Ellis Class II or small Ellis Class III fracture (less than 0.5 mm pulp exposure in size). After all teeth were fractured and the plaster removed, a determination was made as to the acceptability of the fracture obtained. Those teeth deemed unacceptable were discarded. Only 75 of the 200 fractured teeth were deemed acceptable for the study. Each tooth and its fragment were stored together in water until employed in the study.

Luting

Teeth were then randomly assigned into one of three test groups, 25 in each group, based on the luting material used. For group A, a light-cured bonding adhesive and composite resin (Prisma-Fil Universal Bonding Agent and TPH Composite Resin, The LD Caulk Division, Dentsply International, Milford, DE) were used. The teeth were restored by etching the exposed fractured enamel and dentin for 30 s with 37.5% phosphoric acid, rinsing with tap water, and drying with oil-free compressed air. Following this, bonding agent was applied to the two pieces and they were gently meshed together into their original position. While held firmly in place, each side of the reattached tooth was light-cured for 30 s for a total of 2 min. Any small areas of enamel missing from the fracture were replaced with composite resin and cured for 30 s per side. Group B was restored using VariGlass VLC Base (The LD Caulk Division, Dentsply International, Milford, DE) and group C with VariGlass VLC Liner (The LD Caulk Division, Dentsply International, Milford, DE).

For groups B and C, the remnant and fragment were rinsed with tap water and dried lightly with oil-free compressed air without desiccation (the drying time was not measured). Following this, the light-cured glass ionomer base and liner materials were mixed according to manufacturers' recommendations and applied to the exposed enamel and dentin surfaces of the segments. The two pieces were meshed gently together, held firmly and then light cured for 30 s on each surface for a total of 2 min.

Any excess material extruded from the restored fracture lines in groups A, B, and C was gently removed with appropriate hand instruments and finishing burs so that a normal anatomical crown form was achieved. Groups B and C had a bonding agent (Universal Bonding Agent, The LD Caulk Division Dentsply International, Milford, DE) placed on any exposed glass ionomer and light cured for 30 s on each side.

Storage and thermocycling

After restoration, all teeth were stored in tap water at 37°C for 7 days. On the eighth day the restored teeth were thermocycled 2500 times between two baths having a temperature differential of 40°C (5° and 45°C). The dwell time in each bath was 30 s.

Dislodgement test

After thermocycling, all teeth were stored in tap water at 37°C for 7 days. On the eighth day teeth were embedded in a 1-in diameter stone cylinder. To

test the dislodgement strength the embedded teeth were inserted and fitted into a stabilizing jig (Fig 1). The teeth were positioned so that the facial plane of the crown was perpendicular to the applied force. Prior to testing, the incisal segment of each repaired tooth was marked on the facial surface located 1 mm incisal to the repaired fracture. This mark was created with a #4 round bur to standardize application of force to this point of loading. The force was applied to the fragment in a labial-to-lingual direction using a small (1 mm) conical point inserted in the end of a pin which was held in the crosshead of a testing machine (Instron Universal Testing Machine Model 1123, Instron Testing, Park Ridge, IL). The specimens were loaded to failure at a crosshead rate of 0.5 mm/min. The force required to detach the fragment was recorded.

Fracture type

After the dislodgement testing, the fractured surfaces were examined by one investigator (ALM) with a light microscope to determine the nature of the fracture (i.e., cohesive, adhesive, or mixed). The investigator was not blinded to specimen grouping.

Statistical analysis

A one-way ANOVA was performed for statistical evaluation and appropriate multiple comparisons were made by subjecting the data to the Neuman-Kuels test, Student's *t* tests, and Tukey's procedure.

Results

The forces required to fracture each tooth after luting ranged from 5.0 to 116.6 kg and are shown in Table 1. There was no statistically significant difference ($P < 0.05$ ANOVA and multiple comparisons with repeated Student's *t* tests, Newman-Kuels, and Tukey's procedure) in dislodgement strength among the three groups. The type of fracture was determined under a light microscope after dislodgement.

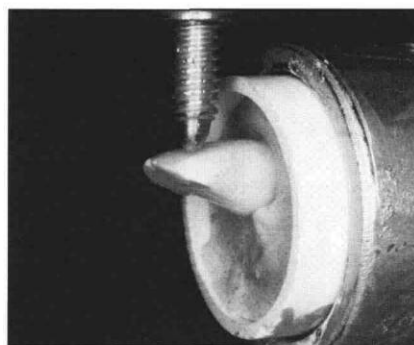


Fig 1. Loading pin seated into dimple prior to activating instron machine.

**TABLE 1. MEAN FRAGMENT DISLODGE-
MENT STRENGTHS**

	<i>Resin (Kg)</i>	<i>GI Base (Kg)</i>	<i>GI Liner (Kg)</i>
Ave	36.8 ± 25.6	36.4 ± 26.8	31.4 ± 29.5

*Values were noted that represented tooth rather than restoration failures. No statistically significant difference between groups at $P < 0.05$; ANOVA and Multiple Comparisons with repeated Student's t tests, Newman-Kuels, and Tukey's Procedure.

**TABLE 2. TYPE OF FRACTURE FROM DISLODGE-
MENT**

	<i>Resin (N)</i>	<i>GI Base (N)</i>	<i>GI Liner (N)</i>
Cohesive	19	18	18
Mixed	3	3	2
Adhesive	0	1	1
Other*	3	3	4

*Values were noted that represented tooth rather than restoration failures. No statistically significant difference between groups at $P < 0.05$; ANOVA and Multiple Comparisons with repeated Student's t tests, Newman-Kuels, and Tukey's Procedure.

Fractures were categorized as:

1. Adhesive (dislodgement at the tooth/material interface)
2. Cohesive (dislodgement within the material)
3. Mixed (combination of adhesive and cohesive)

In all three groups the majority (73%) of the dislodgements were the result of a cohesive fracture with no statistically significant difference ($P < 0.05$ multiple comparisons with repeated Student's t tests, Newman-Kuels, and Tukey's Procedure) in fracture type between the three groups (Table 2).

Discussion

Fracture strength

Glass ionomer has been shown to form a physico-chemical bond with tooth structure⁷⁻⁹ allowing an intimate interlocking. Shear bond strengths of conventional self-curing glass ionomers have been shown to be much weaker when compared to composite resins.^{10, 11} However, light-cured glass-ionomer resin combinations with a "dual set" reaction appear to resolve the problem of the delayed setting reaction of conventional chemically cured glass ionomer cements¹² and have been shown to have shear bond strengths as much as three times higher than chemically cured glass ionomers.¹³⁻¹⁵

It is important to note that we used a light-cured glass ionomer in this study so we could vary its viscosity to test the theory of intimate meshing of the tooth parts in dislodgement strength. The light-cured glass ionomer we used is not generally considered a "true" light-cured glass ionomer, but a glass-ionomer hybrid. At the time this study was initiated, this information was not known. VariGlass powder is a blend of two glasses: strontium and barium boron aluminosilicate. The glasses provide radiopacity and fluoride release. The liquid is polyacrylic acid, PENTA, and visible light-cured active monomers. VariGlass is cured by light activation only.¹⁶ VariGlass lacks the ability to chemically react in the dark which is a property of "true" light-cured glass ionomers. Resin-modified glass ionomers such as Fugii II LC (GC America), Photac-Fil (ESPE Premier), and Vitremer (3M) usually contain a small amount of resin, and thus incorporate properties of both resin and glass ionomer.¹⁷ Due to the composition of VariGlass it cannot be exactly compared to other glass ionomers.

The hybrid light-cured glass-ionomer base and liner used in this study are the same material, differing only in the viscosity. The ratio of powder to liquid is 2:1 for the light-cured glass-ionomer base and 1:1 for the light-cured glass-ionomer liner. Any excess material extruded from the restored fracture lines in groups A, B, and C was gently removed with appropriate hand instruments and finishing burs so that a normal anatomical crown form was achieved. Groups B and C had bonding agent placed on any exposed glass ionomer and were light cured for 30 s on each side.

The results of the dislodgement tests did not show a difference between the three test groups' abilities to bond the tooth fragment to the original tooth remnant. However, the coefficients of variation of the three groups were very large (70-94%) which means that caution must be used in concluding that the three adhesives used are not different. Several factors may have contributed to the variability. One is the angle of the initial fracture. The results of Dean et al.⁴ showed that teeth that had a lingual fracture, and thus lingually supporting tooth structure, withstood labial forces better than teeth without lingual support. In this study, teeth were randomly assigned and it is possible that one group had more of one type of initial fracture. Other variables inherent in this study were the difference in size of each fragment and the distance difference of the loading force from the incisal edge. Distance from the

fracture site was kept consistent at 1 mm, but larger fragment sizes increased the bondable surface area and possibly increased the bond strength.

Ten teeth (3 Resin, 3 GI Base, and 4 GI Liner) did not dislodge at the initial fracture site; instead the loading force fractured the tooth at a new site in the tooth, leaving the luted site intact. This suggests that the dislodgement strength must have been greater than recorded and that there may have been an undiagnosed fracture from the initial hammer blow. Viscosity differences between the luting materials should be considered. Because the viscosity of the hybrid light-cured glass-ionomer base is higher than the hybrid light cured glass-ionomer liner, we theorized that the base group would not be able to accomplish the same intimate meshing of the remnant and fragment. However, the dislodgement strengths between the two forms of glass ionomer are not significantly different, implying that intimate meshing does not provide any additional strength.

Shear strength studies of glass ionomers have shown that the weak link in the bonding of glass ionomer to enamel or dentin is the infrastructure of the glass ionomer, a cohesive failure.¹⁸⁻²⁰ The overwhelming majority of dislodgements were the result of a cohesive failure in both the resin and glass ionomers (composite resin, 76%; glass-ionomer base, 72%; and glass-ionomer liner, 72%) supporting previous studies. Further studies need to compare etched vs. nonetched glass-ionomer reattachments and the relationship of surface area to dislodgement strengths.

Conclusions

The following conclusions can be made from this study

1. There was no statistically significant difference demonstrated ($P < 0.05$) in dislodgement strength between the light-cured resin, the hybrid light-cured glass-ionomer base, and the hybrid light-cured glass-ionomer liner
2. There was no statistically significant difference ($P < 0.05$) in fracture type between the three groups with cohesive fractures occurring 73% of the time.

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Dr. Jeffrey A. Dean is assistant professor of Pediatric Dentistry and Orthodontics, Department of Oral Facial Development, In-

diana University School of Dentistry. Dr. Anthony L. Minutillo is in private practice of pediatric dentistry, Crystal Lake, Illinois. Dr. B. Keith Moore is professor of Dental Materials, Department of Restorative Dentistry, Indiana University School of Dentistry.

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