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Bond Strengths of Two Resin-Modified Glass Polyalkenoate Cements under Different Surface Conditions

ANNE BÉRESS, DMD, MS
ANTHONY H.L. TJAN, DD, DDS, PHD
WILLIS L. SCHLENKER, DDS, MS
TASANEE WONGSRIMONGKOL, DDS, MS

There has recently been an increasing interest in the use of glass polyalkenoate (glass ionomer) cements as orthodontic adhesives.1-4 Conventional glass polyalkenoate cements offer long-term fluoride release and resistance to acid erosion, which is highly advantageous in preventing caries and decalcification around bracket bases.5 Other desirable properties include biocompatibility,6 adhesion to tooth substrate as well as to metals, and the ability to attach chemically to the enamel structure through carboxyl-calcium complexing. Glass polyalkenoate cements also allow a longer working time and are easier to clean up after debonding than other adhesives.7 Unfortunately, they have demonstrated much lower bond strength.1,8

Resin-modified glass polyalkenoate cements combine the advantages of conventional glass polyalkenoates with the mechanical and physical properties of composite resin luting agents. They have an accelerated setting reaction, greater initial strength and hardness, and reduced sensitivity to moisture contamination.9,10 They have demonstrated at least three to four times the compressive and tensile strength of chemically cured glass polyalkenoates.2,11

The resin-modified glass cements have the additional advantage of mechanical interlocking with etched enamel. However, the etching could cause a loss of enamel structure and increase the accumulation and retention of bacterial plaque on the enamel surface.12,13

One commercially available resin-modified glass polyalkenoate, Fuji Ortho LC, consists of a finely ground fluoroaluminosilicate glass and a liquid mixture of polyacrylic, water, monomer, and activator. The resin component is a mixture of three monomers with 2-hydroxyethyl methacrylate (HEMA). Camphoroquinone is added as a photoinitiator to speed up the setting reaction to light. Another resin-modified glass polyalkenoate, Vitremer, contains fluoroaluminosilicate glass and a light-sensitive aqueous solution of a modified polyalkenoic acid. HEMA, in the form of a hydrophilic monomer, is the major constituent of the liquid.

These new cements appear to provide adequate clinical bond strength without etching.14 The manufacturers also claim that they exhibit greater bond strength in a moist environment.

The purpose of the present study was to measure the shear bond strengths of metal brackets bonded with these two resin-modified glass polyalkenoate cements to both etched and unetched and to both moist and dry enamel surfaces.

Materials and Methods

Sixty freshly extracted human molars were cleaned and stored in an incubator of 37°C water. Just before bonding, each tooth was polished with nonfluoridated pumice for 20 seconds at a low speed. It was then mounted on a phenolic ring with epoxy resin (Fig. 1). The teeth were randomly divided into six groups of 10:

- 1. Fuji Ortho LC–etched enamel, dry surface
- 2. Fuji Ortho LC–etched enamel, moist surface
- 3. Fuji Ortho LC–unetched enamel, dry surface
- 4. Fuji Ortho LC–unetched enamel, moist surface
- 5. Vitremer–etched enamel, moist surface
- 6. Vitremer–unetched enamel, moist surface

An experimental batch of Vitremer was used. Both cements were mixed according to the manufacturers' instructions and light-cured for 40 seconds per bracket. The etched enamel surfaces were conditioned for 20 seconds with 37% phosphoric acid, thoroughly rinsed with water for 20 seconds, and dried for five seconds. In the groups with moist conditions, a wet cotton roll was applied to each enamel surface before bonding.

The same type of edgewise metal brackets were bonded to all the teeth. The bonded specimens were aged for seven days in 37℃ water and thermocycled 300 times between 5°C and 55°C, with 30 seconds at each temperature, to simulate the ingestion of hot and cold food. The samples were stored in the incubator for seven more days before debonding.

Each specimen was mounted in a specially designed jig that positioned the bracket-tooth interface parallel to the applied force (Fig. 2). Shear bond strength was measured in MPa on an Instron Universal Tester (Model 1125), set at a crosshead speed of 1 mm/minute.

Data were compared by analysis of variance and Bonferroni/Dunn tests, with statistical significance determined at a level of .05.

Results

The etched groups showed significantly greater shear bond strengths than the unetched groups (Table 1, Fig. 3). However, there were no significant differences in bond strength among any of the etched samples or among the unetched samples, and no significant differences between dry and moist surfaces or between the two types of glass polyalkenoate cements.

Discussion

Acid etching can cause decalcification and loss of enamel. As much as 160 microns of enamel loss have been found after etching and debonding.12,13 Retention of resin tags between the enamel prisms and even adverse skin reactions to etching have been reported.15

Maijer and Smith16 considered 8-10 MPa to be a minimal acceptable bond strength, whereas Ewoldsen and colleagues17 estimated a bond strength of greater than 3-5 MPa to be clinically acceptable. In either case, the bond strengths of the unetched groups in this investigation (5.3-5.9 MPa) would be borderline at best for withstanding occlusal and orthodontic forces. In addition, it must be remembered that this study was conducted in vitro, and that additional forces and contaminants that could lead to even greater bond failure rates would be present in the mouth.

Etching the enamel surfaces provided a micromechanical retention to the resin tags in the enamel, in conjunction with the chemical carboxyl-calcium binding of the adhesives. The resulting bond strengths of 17.2-17.9 MPa are comparable to those of composite resin luting agents.18

Debonding caused saucer-shaped enamel fractures in 50% of the etched Fuji Ortho LC specimens.

Although the extracted teeth were more brittle than live teeth would be, this finding should be taken into account when considering bonding procedures.

According to the manufacturer of Fuji Ortho LC, moisture aids in the bonding reaction, whereas a desiccated or overdried surface will adversely affect bond strength. In this study, however, there was no significant difference in shear bond strength between the dry and moist and enamel surfaces bonded with Fuji Ortho LC. The presence of HEMA (which is also the hydrophilic constituent of Vitremer) might explain this behavior of the Fuji adhesive.

There was also no significant difference in this study between the bond strengths achieved with Fuji Ortho LC and Vitremer Experimental among either the etched or the unetched groups.

Further research is under way into the influence of long-term storage of brackets bonded with resin-modified glass polyalkenoate cements on etched surfaces, to determine whether degradation of the cements in water adversely affects bond strength. □

FIGURES

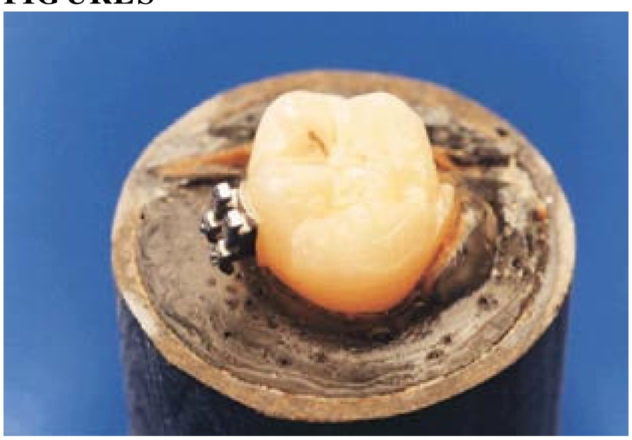

Fig. 1 Typical mounted specimen.

Fig. 2 Shear force applied to bracket in Instron machine.

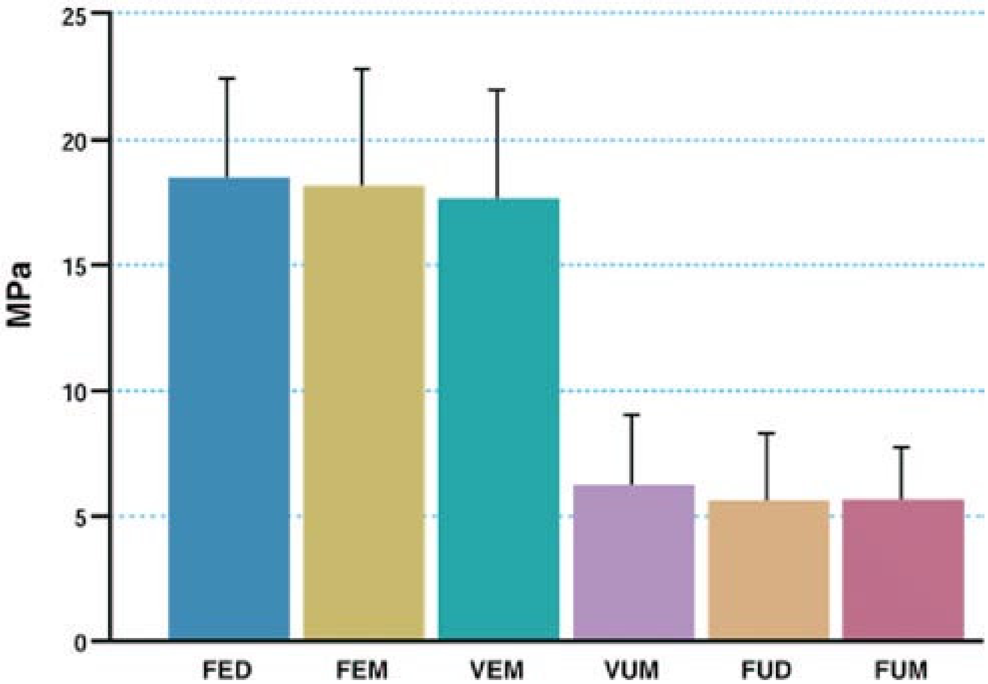

Fig. 3 Mean shear bond strengths and standard deviations of two resin-modified glass polyalkenoate cements under different surface conditions (F = Fuji Ortho LC; V = Vitremer; E = etched; U = unetched; D = dry; M = moist).

TABLES

TABLE 1
SHEAR BOND STRENGTHS (MPa)

Adhesive	Surface Conditions	Mean	S.D.
1. Fuji Ortho LC	Etched, dry	17.95	3.98
2. Fuji Ortho LC	Etched, moist	17.69	4.60
3. Fuji Ortho LC	Unetched, dry	5.34	2.58
4. Fuji Ortho LC	Unetched, moist	5.27	2.15
5. Vitremer	Etched, moist	17.20	4.36
6. Vitremer	Unetched, moist	5.91	2.76

Table. 1

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FOOTNOTES

1 Fuji Ortho LC: GC America Inc., 3737 W. 127th St., Chicago, IL 60658.

2 Vitremer: 3M Unitek, 2724 S. Peck Road, Monrovia, CA 91016.

3 Phenolic ring: Buehler Ltd., 41 Waukegan Road, Lake Bluff, IL 60044.

4 Light cure: Optilux 400, Demetron/Kerr, 21 Commerce Drive, Danbury, CT 06810.

5 Phosphoric acid: Ultra-Etch, Ultradent Products Inc., 505 W. 10200 South, South Jordan, UT 84095.

6 Metal brackets: "A" Company Orthodontics, 9900 Old Grove Road, San Diego, CA 92131.

7 Universal Tester: Instron Corporation, Canton, MA.