SHORT COMMUNICATION

Shear bond strength of a resin-reinforced glass ionomer cement: An in vitro comparative study

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Shear bond strength of Concise (a composite resin adhesive) and Fuji Ortho LC (a light-cured resin-reinforced glass ionomer cement) bonded to extracted teeth was tested under different bonding conditions: (1) Concise/etched/dry (2) Fuji/etched/dry (3) Fuji/etched/wet (4) Fuji/unetched/dry (5) Fuji/unetched/wet. Concise/etched/dry and Fuji/etched/dry groups showed comparable mean shear bond strength (10.5 and 8.2 MPa, respectively); the other three groups had considerably lower values. The difference between Fuji/etched/dry and Fuji/etched/wet was not statistically significant. The site of bond failure was between bracket and adhesive in all etched groups and between adhesive and enamel in the unetched groups. We conclude that (1) enamel surface etching is required for Fuji Ortho LC to achieve optimum bond strength, (2) moisture does not affect bond strength of Fuji Ortho LC significantly. (Am J Orthod Dentofacial Orthop 1999;115:52-4)

Glass ionomer cement (GIC) is characterized by the ability to bond chemically to enamel and dentine without etching these surfaces,[1] and release fluoride ions to the vicinity.[2,3] These features are responsible for the wide usage of GIC in orthodontic banding.[4,5] However, the cement is not recommended for bonding orthodontic brackets because of its lower bond strength and higher bond failure rate when compared with composite resin.[6,7]

To increase the bond strength, some resins, such as hydroxydimethacrylate and BIS-GMA, are added to GIC. Most manufacturers of this resin-reinforced or hybrid GIC recommend that the enamel surface be etched with a weak acid conditioner (10% to 25% polyacrylic acid or 3% nitric acid) or with 37% phosphoric acid, and dried before bonding. The resin-reinforced GIC has proved to have a higher shear bond strength than conventional chemically cured GIC in vitro,[8,9] but still lower than composite resin.[10] Thus, the hybrid cement has been recommended for bonding brackets on anterior, not posterior teeth.[11]

Recently, a resin-reinforced GIC, Fuji Ortho LC (GC America Inc, Chicago, Ill) was developed that, according to the manufacturer, can bond brackets to a tooth surface that is either acid-etched or unetched and wet. In a clinical study where Fuji Ortho LC was bonded on maxillary and mandibular teeth (from first molar to first molar for most patients) without etching, and in the presence of saliva, Silverman et al[12] reported a success rate of 96.8% over a period of 8 months. A control group was not included in the study. In an in vitro study, Jobalia et al[13] reported that Fuji Ortho LC had an optimum tensile bond strength comparable to that of composite resin when bonded to etched and wet enamel. They did not test the bond strength when the enamel surface is etched and dried.

The purpose of this study was to evaluate the bond strength of the same resin-reinforced GIC (Fuji Ortho LC) in vitro under various conditions of surface preparation and moisture.

MATERIAL AND METHODS

One hundred freshly extracted noncarious human premolars were stored in distilled water. Each tooth was mounted in a copper tube of $^3/_4$ inch in diameter and $2^1/_2$ inch in length using yellow stone. The samples were then stored in an airtight humid environment to prevent dehydration, and randomly divided into 5 groups of 20 teeth each.

The following procedures were similar for preparing teeth in all groups: (1) the facial surface of each tooth was cleaned for 30 seconds with nonfluoride oil-free pumice paste placed in a prophy cup attached to a low-speed handpiece; (2) the tooth was rinsed with water and dried with an oil-free air spray

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for 30 seconds. When indicated, the etching procedure consisted of placing 37% phosphoric acid for 20 seconds (as per the manufacturer's directions) on the enamel surface, which was subsequently rinsed with air and water spray for 30 seconds and dried with an air spray. All brackets were placed on the buccal surface of the tooth along the axis of the crown. Excess bonding material was removed with an explorer without disturbing bracket placement. In all groups, the bond was allowed to set at 37°C and 100% relative humidity for 24 hours, the time required for the final setting of the bonding material. When applicable, a thin layer of whole, unstimulated, fresh human saliva, collected from one of us (PTC), was coated on the tooth surface.

Group 1: Enamel etched, dried, and then bonded with Concise (3M Unitek, Monrovia, Calif).

A thin coat of sealant was applied to the enamel. Equal amounts of two pastes (A and B) were mixed and applied to the mesh of the bracket.

Group 2: Enamel etched, dried, and then bonded with Fuji Ortho LC.

Two drops of liquid were mixed with one scoop of powder and applied to the mesh of the bracket. The bond was light cured on all four sides for a total of 50 seconds (manufacturer's recommendation).

Group 3: Enamel etched, dried, coated with human saliva, and then bonded with Fuji Ortho LC.

Group 4: Unetched enamel, dried and bonded with Fuji Ortho LC.

Group 5: Unetched enamel, moistened with human saliva and then bonded with Fuji Ortho LC.

All brackets (mini uni-twin, 3M Unitek) were bonded by one operator (PTC); 24 hours later they were tested in shear mode with a universal testing machine (Instron Corp, Canton, Mass) set at a crosshead speed of .5 mm/min (Fig 1). The shear force required to debond each bracket was recorded in newtons and converted into megapascals (MPa) as a ratio of newtons to surface area of the bracket. The brackets and teeth were inspected visually to evaluate the site of bond failure.

The data were tested for normality by the Kolmogorov-Smirnov method. Differences between the groups were then evaluated by a one-way analysis of variance. When the data were not normally distributed, a Kruskal-Wallis ANOVA was performed. Pairwise multiple comparisons between the various groups were made by the Dunn's method ($P < .05$).

RESULTS

The etched teeth had the highest shear bond strength means, Concise yielding the strongest values, and Fuji Ortho LC under dry conditions providing a stronger bond than under wet conditions (Table I). When the tooth surface was not etched, the shear bond strength of Fuji Ortho LC was low, in either dry or wet environment.

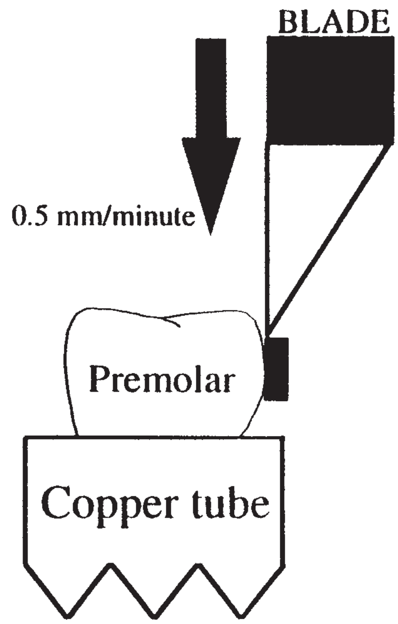

Fig 1. Schematic representation of specimen in Instron machine. Blade is directed parallel to long axis of crown of tooth.

The site of bond failure was apparently related to the condition of the tooth surface. In the etched groups, the bond failed between bracket and adhesive (Table I). In the unetched Fuji groups, the site of failure was between adhesive and enamel, and no bonding material remained on the enamel surfaces.

DISCUSSION

The findings indicate that when the tooth surface is etched and dried, the resin-reinforced glass ionomer is comparable to Concise and would be expected to provide successful bonding. However, the reason for introducing Fuji Ortho LC is the claim that it works under less stringent operative conditions, namely, unetched enamel and wet environment.

When the tooth surface was etched but not dried, the mean bond value (5.31 MPa) was not statistically significantly different from the Fuji/etched/dry group (8.16 MPa). A tensile bond strength of approximately 4.9 MPa was suggested as sufficient for clinical success,[14] but a corresponding shear bond strength is not available in the literature. Nonetheless, the present data suggest that the Fuji product may be used, preferably

Table I. Shear bond strength and the site of bond failure

		Bond strength (MPa)			*Failure site (%)*	
Group	*N*	*Mean*	*SD*	*Range*	*Br-Ad†*	*Ad-En‡*
1 Concise/etched/dry	18*	10.52	3.62	5.65-19.10	100	0
2 Fuji/etched/dry	18*	8.16	2.46	4.57-13.45	100	0
3 Fuji/etched/wet	20	5.31	2.46	1.88-12.91	100	0
4 Fuji/unetched/dry	20	2.11	1.61	0.54-7.26	0	100
5 Fuji/unetched/wet	20	2.96	1.89	0.81-7.26	0	100

Pairwise comparisons statistically significant ($P < .05$) for groups 1 and 3; 1 and 4; 1 and 5; 2 and 4; 2 and 5; 3 and 4.
*Two samples were excluded for technical errors (see text).
†Between bracket and adhesive.
‡Between adhesive and enamel.

after etching, when a complete control of moisture is not achievable, for example, when bonding permanent second molars with difficult access or impacted teeth after surgical exposure.

In the absence of acid etching, Fuji had lower shear bond strength on either dry (2.11 MPa) or wet enamel (2.96 MPa) than in etched groups. These results seemingly do not support the findings of Silverman et al[12] who reported a high rate of success (96.8%) when Fuji Ortho LC was applied on unetched teeth in the presence of saliva. This apparent discrepancy suggests one of the following possibilities: (1) a shear bond strength of about 3 MPa is sufficient to sustain the forces to which the bracket is exposed; or (2) the clinical conditions are not comparable to in vitro settings and the range of variation in vitro does not reflect the clinical variation. Silverman et al[12] initiated treatment during a period of 8 months. Presumably, they reported on brackets that were bonded for periods less than and up to 8 months. Thus, follow-up study of their population is needed to ascertain their conclusion. Moreover, a clinical study is warranted to evaluate the bond failure with Fuji Ortho LC under different bonding conditions.

The site of bond failure between adhesive and bracket base in all etched groups and between adhesive and enamel in unetched groups was consistent with the fact that shear strength was stronger when the teeth were etched. Failure at the bracket/enamel interface after bonding with Fuji Ortho LC on unetched and saliva-moistened enamel was in contradiction to the findings of Jobalia et al[13] regarding tensile strength. Under similar experimental conditions, these authors reported failure at the adhesive/bracket interface in the majority (70%) of their sample.

Two samples from each of groups 1 and 2 were discarded because they failed with an uncharacteristic lack of resistance when the blade started hitting the brackets. This failure was apparently related to surface contamination during bonding.

The ranges of shear bond strength were high in all groups (Table I). This variation may reflect the diversity in proper fit between bracket base and the anatomically variable buccal curvature of the crowns. Another reason for the wide variation may be the inability of the operator to position the Instron blade precisely. Interestingly, most in vitro studies[10,13] reveal a wide range of variation, an observation that underlines the importance of conducting clinical research.

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