Bond Strengths of a Resin-Modified Glass Ionomer with Five Orthodontic Brackets

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Metal orthodontic brackets are designed with a variety of bonding pads and retention mechanisms. Previous studies have tested the bond strengths of different pad designs with composite resin adhesives.[1,2] Since that research was conducted, however, new materials and pad designs have been introduced to the market.

Resin-modified glass ionomer cements have been recommended for bonding brackets because of their fluoride-releasing properties and the resulting possibility of reducing enamel demineralization around the brackets.[3,4] One such cement, Fuji Ortho LC,* has been shown to have clinically adequate bond strength when applied to 100-gauge foil mesh bonding pads.[5] The objective of the present study was to measure the shear bond strength of this light-cured glass ionomer with five different bracket designs.

Materials and Methods

Sixty-five human premolars stored in .1% thymol were cleaned with water, pumice, and a rubber cup, then rinsed with water. The teeth were randomly divided into five groups of 13 each, to be bonded with the following premolar brackets (Fig. 1):

Group 1—Dentaurum Discovery** titanium brackets with laser-etched pads

Group 2—GAC MicroArch*** twin brackets with Supermesh,*** a 200-gauge foil mesh layer covered by a 100-gauge foil mesh layer

Group 3—Unitek Miniature Twin**** stainless steel brackets with cast stainless steel pads

Group 4—Ormco Diamond† full-size twin brackets with Ormesh† 100-gauge foil mesh pads

Group 5—Ormco Mini Diamond† twin brackets with Optimesh,† a 100-gauge foil mesh that has been metallic-coated and silanated

Each tooth was etched with a 35% orthophosphoric acid gel‡ for 30 seconds, rinsed with water, and kept moist until bonding. Each bracket was bonded to the buccal surface with Fuji Ortho LC, according to the manufacturer's instructions, and cured for 40 seconds with an Ortholux XT light-curing unit.****

The samples were mounted in acrylic resin cylinders, using a jig to properly position the brackets for debonding in the Zwick Materials Testing Machine†† (Fig. 2). Bonded teeth were stored for 24 hours in deionized distilled water at 37°C. Each sample was tested to failure at a crosshead speed of .5cm/minute.

Mean shear bond strengths were calculated for each group. The values were compared by analysis of variance and Duncan's multiple-range test.

The Adhesive Remnant Index[6] (ARI) was recorded for all debonded specimens that showed no enamel damage, using the following scale to grade the amount of adhesive remaining on the tooth surface:

1 = 0%
2 = more than 0% to 25%
3 = more than 25% to 50%
4 = more than 50% to 75%
5 = more than 75% to less than 100%
6 = 100%

*Trademark of GC America, Inc., 3737 W. 127th St., Alsip, IL 60803.

**Registered trademark of Dentaurum, Inc., 10 Pheasant Run, Newtown, PA 18940.

***Registered trademark of GAC International, Inc., 185 Oval Drive, Central Islip, NY 11722.

****Trademark of 3M Unitek, 2724 S. Peck Road, Monrovia, CA 91016.

†Registered trademark of Ormco/"A" Company, 1717 W. Collins Ave., Orange, CA 92867.

‡Ultradent Products, Inc., 505 West 10200 South, South Jordan, UT 84095.

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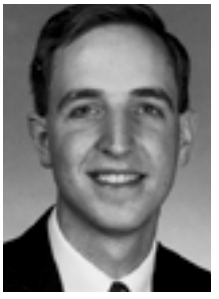

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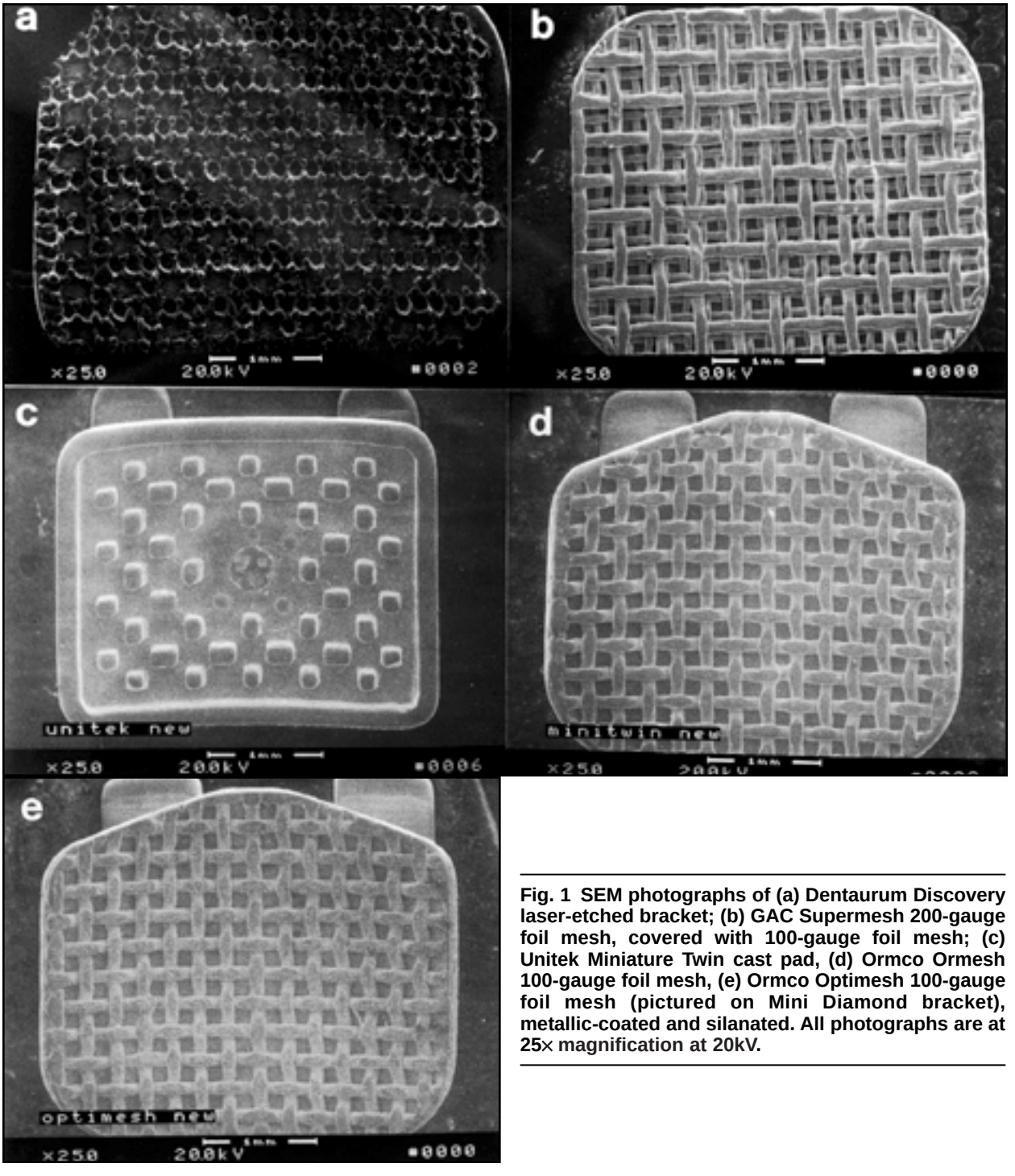

Fig. 1 SEM photographs of (a) Dentaurum Discovery laser-etched bracket; (b) GAC Supermesh 200-gauge foil mesh, covered with 100-gauge foil mesh; (c) Unitek Miniature Twin cast pad, (d) Ormco Ormesh 100-gauge foil mesh, (e) Ormco Optimesh 100-gauge foil mesh (pictured on Mini Diamond bracket), metallic-coated and silanated. All photographs are at 25× magnification at 20kV.

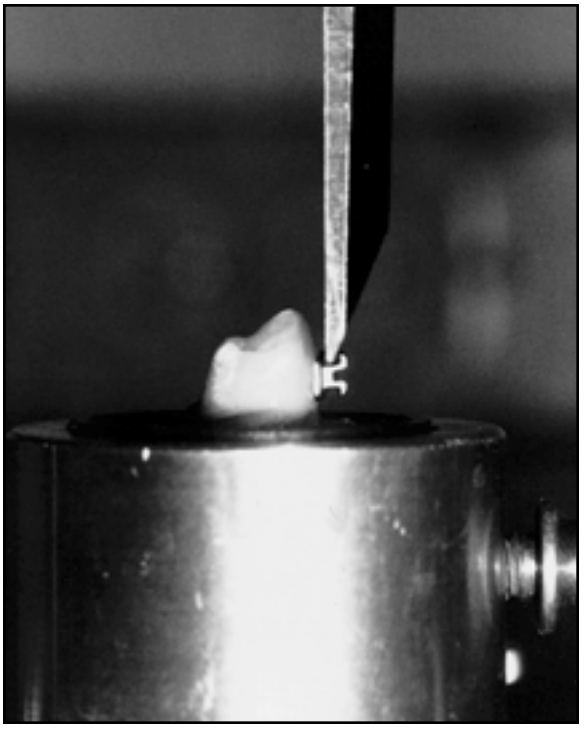

Fig. 2 Bonded tooth in Zwick Materials Testing Machine.

Results

Four samples (one GAC Supermesh bracket and three Ormco Ormesh brackets) were lost because of catastrophic failures involving fracture of the entire buccal cusp. One tooth was discarded because the chisel struck the acrylic mounting material (GAC Supermesh), and another was lost because of accidental bracket failure before testing (Unitek Miniature Twin).

Mean shear bond strengths ranged from a high of 17.2 MPa for Ormco Ormesh to a low of 7.7 MPa for GAC Supermesh (Table 1). Analysis of variance indicated a significant difference among the different bracket types ($p < .001$). Duncan's test, however, showed that the mean shear bond strength of the GAC Supermesh brackets was significantly lower than those of the other bracket groups ($p < .05$), all of which had similar bond strengths.

Enamel damage on debonding occurred with the following frequencies: Dentaurum Discovery, 62%; Ormco Ormesh, 50%; Ormco Optimesh, 23%; and Unitek Miniature Twin, 17%. A t-test showed that the shear bond strengths of the enamel-damaged samples ($N = 18$) were significantly greater ($p < .015$) than those of the undamaged teeth ($N = 41$). Such debonding damage has previously been related to higher bond strengths in shear testing.[7]

In the ARI scoring, the Dentaurum Discovery brackets left the least adhesive remnant on the enamel, and the GAC Supermesh brackets left the greatest amount of adhesive (Table 2).

Discussion

The catastrophic failures of four teeth could be explained by damage during extraction, weakening during storage, or weakening due to stresses within the crown caused by the shear testing. Enamel damage is a common problem in shear bond testing that has been associated with higher nominal bond strengths, slower crosshead speeds, and greater load offset.[7] It appears that the testing creates stress in the enamel, causing it to be pulled out of the tooth along with the adhesive.

The mean shear bond strength of the Ormco Ormesh brackets (17.2 MPa) was similar to the mean value at 24 hours for the same bracket and adhesive bonded under similar conditions in a previous study[5] (16.8 MPa). In the earlier study, the mean shear bond strength for Ormco Ormesh brackets bonded to etched enamel with Fuji Ortho LC was statistically equivalent to the bond strength of the same brackets bonded to etched enamel with a composite resin. This suggests that the other brackets in this study with bond strengths statistically equivalent to the Ormco Ormesh brackets (Dentaurum Discovery, Unitek Miniature Twin, and Ormco Optimesh)

TABLE 1
SHEAR BOND STRENGTHS OF FUJI ORTHO LC (MPa)

	N	Mean	S.D.	Range	Duncan's Letter*
Dentaurum	13	13.8	3.4	8.1-20.5	A
GAC	11	7.7	1.8	5.4-10.6	B
Unitek	12	13.1	5.2	6.6-24.9	A
Ormco Ormesh	10	17.2	5.1	12.3-30.3	A
Ormco Optimesh	13	15.9	7.1	7.6-34.7	A

Degrees of freedom = 4; F = 6.02; p = .0004.
*Groups with same letter are not different ($p \leq .05$).

TABLE 2
MEAN ADHESIVE REMNANT INDEX SCORES

Dentaurum	1.6
GAC	4.3
Unitek	4.0
Ormco Ormesh	3.0
Ormco Optimesh	2.6

would also have similar bond strengths when used with composite resins.

The results of this study suggest that the above four bracket types would be suitable for bonding with Fuji Ortho LC. One bracket, the GAC MicroArch with Supermesh, did not appear to achieve adequate bond strength with the glass ionomer. Perhaps the adhesive was not able to completely penetrate the two layers of mesh on the bonding pad. The GAC Supermesh samples also showed the greatest amount of adhesive remnant following removal of the brackets, suggesting that the bonds were weakest near the bracket pads. Further testing should be conducted to see if similar results are obtained in vivo.

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