Original Article

A Self-Conditioner for Resin-Modified Glass Ionomers in Bonding Orthodontic Brackets

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ABSTRACT

Objective: To evaluate a new self-etch conditioner used with resin-modified glass ionomers (RMGIs) in bonding orthodontic brackets.

Materials and Methods: Sixty human molars were cleaned, mounted, and randomly divided into three groups. In group 1 (control), 20 orthodontic brackets were bonded to teeth using Transbond Plus Self-etching Primer; in group 2, 20 brackets were bonded using an RMGI with a 10% polyacrylic acid conditioner. In group 3, 20 brackets were bonded using Fuji Ortho LC with a new no-rinse self-conditioner for RMGIs. The same bracket type was used on all groups. The teeth were debonded in shear mode using a universal testing machine, and the amount of residual adhesive remaining on each tooth was evaluated. Analysis of variance was used to compare the shear bond strength (SBS), and the χ^2 test was used to compare the Adhesive Remnant Index (ARI) scores.

Results: There were no significant differences in the SBS ($P = .556$) between the groups. The mean SBS for Transbond Plus was 8.6 ± 2.6 MPa, for Fuji Ortho LC using 10% polyacrylic acid 9.1 ± 4.6 MPa, and for Fuji Ortho LC using GC Self-conditioner 9.9 ± 4.1 MPa. The comparisons of the ARI scores between the three groups ($\chi^2 = 35.5$) indicated that bracket failure mode was significantly different ($P < .001$), with more adhesive remaining on the teeth bonded using Transbond.

Conclusions: The new self-etch conditioner can be used with an RMGI to successfully bond brackets. In addition, brackets bonded with Fuji Ortho LC resulted in less residual adhesive remaining on the teeth.

KEY WORDS: Self-etch; Resin-modified glass ionomer; Bonding; Brackets

INTRODUCTION

In their attempt to minimize the incidence of decalcification around orthodontic appliances, orthodontists have always emphasized the need for good oral hygiene[1] as well as the role of fluoride in preventing caries.[2,3] As a result, the application of fluoride solutions topically to the etched tooth during bonding and the use of fluoride rinses during treatment are recommended.[4] In addition, several fluoride-releasing cements have been developed and used clinically to reduce decalcification.[5–7]

Glass ionomer cements (GICs) were initially introduced as orthodontic bonding adhesives to take advantage of some of their desirable characteristics, namely, their ability to chemically bond to tooth structure[8,9] and sustain fluoride release following bonding.[10–17] Fluoride release was shown to increase in the plaque adjacent to brackets bonded with GICs,[18] but their use in orthodontics was limited because of their lower bond strengths.[19–25] In an attempt to increase the bond strengths of GICs, resin particles were added to their formulation to create resin-modified glass ionomers (RMGIs). These adhesives release fluoride-like conventional GICs and were used to bond orthodontic brackets because of their relatively higher bond strengths.[26–31] However, RMGIs have lower shear bond strength (SBS) compared to composite resins,[32–35] particularly within the first half hour after bond-

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ing,[36] but they are still able to bond orthodontic brackets successfully.[34–38] In addition, in vivo studies have shown no significant differences in bracket failure rates between the two adhesive groups.[32] In an effort to improve the SBS of RMGIs on orthodontic brackets, various enamel conditioners have been evaluated for use with RMGIs. It was observed that teeth conditioned with 10% polyacrylic acid had an SBS that was significantly lower than teeth conditioned with 37% phosphoric acid before bonding with RMGIs.[39,40] Increasing the polyacrylic acid concentration to 20% resulted in an eightfold increase in SBS; however, this SBS was still significantly lower than that of teeth conditioned with phosphoric acid.[40] Although self-etching primers (SEPs) are typically designed for use with composite resins, a recent study evaluated using an SEP with an RMGI to bond brackets. Greater bond strengths were observed in teeth conditioned with the SEP when compared to teeth conditioned with either 10% polyacrylic acid or 37% phosphoric acid etchants.[41]

While conventional SEPs have been marketed for use with composite resins, a new no-rinse self-conditioner (GC Self-conditioner; GC America, Alsip, Ill) has been developed for use specifically with RMGI restorative materials. When used on enamel and dentin, this self-etch conditioner produced a similar microtensile bond strength as that obtained with a 25% polyalkenoic acid conditioner,[42] with the added advantage of not having to be rinsed off following application. However, its ability to bond orthodontic brackets when used with an RMGI has not been evaluated. Thus, the purpose of this study was to determine if the new self-conditioner designed for use with an RMGI could successfully be used to bond orthodontic brackets by providing an acceptable SBS.

MATERIALS AND METHODS

Teeth

Sixty freshly extracted human molars were collected and stored in a solution of 0.2% (weight/volume) thymol. To meet the criteria for use in the study, the teeth were selected only if they had intact buccal enamel, had not been pretreated with chemical agents (eg, H_2O_2), had no surface cracks from extraction forceps, and were free of caries. The teeth were embedded in dental stone placed in phenolic rings (Buehler Ltd, Lake Bluff, Ill).

A mounting jig was used to align the facial surfaces of the teeth perpendicular with the bottom of the mold. This kept the buccal surface of the tooth parallel to the applied force during the shear test. Following mounting, the teeth were cleaned and polished with pumice and rubber prophylactic cups for 10 seconds.

Brackets

Orthodontic lateral incisor metal brackets of the Victory series (3M Unitek, Monrovia, Calif) were used in the study. The average surface area of the bracket base was determined to be 10.3 mm^2. This was determined by randomly measuring five bracket bases.

Groups Tested

Group 1 (control). Twenty teeth were bonded with precoated APC Plus metal brackets (3M Unitek) using the Transbond Plus Self-etching Primer system. Transbond Plus uses a lolipop system that has two compartments: one contains methacrylated phosphoric acid esters, initiators, and stabilizers, while the other compartment contains water, fluoride complexes, and stabilizers. To activate the product, the two compartments were squeezed so that the contents of each compartment were allowed to mix. The resulting mix was then applied to the tooth surface for 3 to 5 seconds. The SEP was lightly dried with compressed air for 2 seconds. Each bracket was applied to the tooth using a 300-g force (Correx force gauge, Bern, Switzerland) to ensure a uniform thickness of adhesive. Excess adhesive was removed with a sharp scaler, and the bracket was light cured with a halogen light for 20 seconds.

Group 2. Twenty teeth were etched using 10% polyacrylic acid enamel conditioner. Following the manufacturers' instructions, the conditioner was applied for 20 seconds, and the tooth was then thoroughly rinsed with water. Excess water was blotted away using a moist cotton roll. The capsules containing the RMGI Fuji Ortho LC were activated and triturated at 4000 rpm for 10 seconds. Capsules were placed in the GC Capsule Applier (GC America Inc) to place the adhesive on each bracket. Excess adhesive was removed using a sharp scaler, and the bracket was light cured with a halogen light for 40 seconds (10 seconds each from the mesial, distal, occlusal, and gingival sides).

Group 3. On the remaining 20 teeth, the new self-conditioner designed to be used with RMGIs, GC Self-conditioner (GC America Inc), was used to prepare the enamel surfaces for bonding. This self-conditioner contains 2-hydroxyethyl methacrylate, 4-methacryloxyethyltrimellitate anhydride, ethanol, and water. Following the manufacturers' instructions, a thin layer of the self-conditioner was applied to the enamel surface with a micro-tip applicator and left undisturbed for 10 seconds. The surface was then dried using compressed air for 5 seconds. The capsules containing the RMGI Fuji Ortho LC were activated and triturated similar to group 2. The adhesive was applied to the bracket, and the teeth were light cured as described for group 2.

Table 1. Descriptive Statistics in Megapascals (MPa) and the Results of the Analysis of Variance for the Comparisons Between the Three Groups Tested[a]

Group	Conditioner	Adhesive	n	$\bar{x}$	SD	Range
1	Transbond Plus	Composite resin	20	8.6	2.6	3.4–12.0
2	10% polyacrylic acid	RMG1	20	9.1	4.6	1.2–15.2
3	GC Self-conditioner	RMG1	20	9.9	4.1	0.2–18.2

[a] $\bar{x}$ = mean; SD = standard deviation; P = probability; RMG1 = resin-modified glass ionomer. *F* ratio = 0.59; *P* = .556.

Debonding Procedure

The SBS of each group was determined within half an hour from the time of bonding, to simulate the clinical conditions when arch wires are first tied to newly bonded teeth. A steel rod with a flattened end was attached to the cross-head of a Zwick testing machine (Zwick GmbH, Ulm, Germany). The rod applied an occlusogingival load to test the bracket-tooth interface in a shear mode to the complete failure of the bonded bracket. The results of each test were recorded by a computer that was electronically connected to the testing machine. The Zwick machine (cell capacity = 50 kN) recorded the results from each test in megapascals (MPa) at a cross-head speed of 5.0 mm/min.

Adhesive Remnant Index

Once the brackets were debonded, the enamel surface of each tooth was examined under ×10 magnifications to determine the amounts of residual adhesive remaining on each tooth. A modified Adhesive Remnant Index (ARI) was used to quantify the amount of remaining adhesive using the following scale: 1 = all the adhesive remained on the tooth, 2 = more than 90% of the adhesive remained on the tooth, 3 = between 10% and 90% of the adhesive remained on the tooth, 4 = less than 10% of the adhesive remained on the tooth, and 5 = no adhesive remained on the tooth.

Statistical Analysis

An analysis of variance was used to determine whether there was a significant difference in SBSs between the three test groups. A χ^2 test was used to compare the bond failure mode (ARI scores) between the three groups. For the purpose of statistical analysis, the ARI scores 1 and 2 as well as 4 and 5 were combined. Significance for all statistical tests was predetermined at $P \leq .05$.

RESULTS

Shear Bond Strength

The descriptive statistics including the mean, standard deviation, and minimum and maximum values for the three groups are presented in Table 1. The mean SBS for the brackets bonded using the Transbond Plus system was 8.6 ± 2.6 MPa; for the traditional 10% polyacrylic acid conditioner + RMGI, 9.1 ± 4.6 MPa; and for the new self-conditioner + RMGI, 9.9 ± 4.1 MPa. The results of the analysis of variance (F = 0.59) indicated there were no statistically significant differences (P = .556) between the groups.

Table 2. Frequency Distribution of the Modified Adhesive Remnant Index (ARI) Scores and the Result of the χ^2 Comparisons Between the Three Groups Tested[a]

		Modified ARI Scores[b]				
Group	n	1	2	3	4	5
1	20	12	5	2	1	—
2	20	1	—	2	8	9
3	20	—	3	2	7	8

[a] χ^2 = 35.5; $P < .001$.
[b] 1 indicates all composite remained on the tooth; 2, more than 90% of the composite remained on the tooth; 3, 10% to 90% of the composite remained on the tooth; 4, less than 10% of the composite remained on the tooth; 5, no composite remained on the tooth.

Adhesive Remnant Index

The failure modes of the three groups are presented in Table 2. The χ^2 comparisons of the ARI scores between the three groups (χ^2 = 35.5) indicated that bracket failure modes were significantly different ($P <$ .001). In the Transbond group, most of the bond failure was at the bracket/adhesive interface (groups 1 and 2), while in both groups bonded with the RMGI, the bond failure was at the enamel-adhesive interface (groups 4 and 5).

DISCUSSION

Traditional methods of bonding orthodontic brackets to teeth have relied on the use of the acid-etch technique to achieve adequate retention. The bonding procedure can be improved by minimizing enamel loss, decreasing enamel demineralization adjacent to brackets, and decreasing technique sensitivity while still providing adequate SBS. With such advances, the clinician can effectively reduce chair time and increase cost-effectiveness, resulting in increased convenience and reduced costs for the patient.

RMGIs have been used as bracket-bonding adhesives because of their fluoride-releasing capabilities and ability to bond orthodontic brackets with acceptable SBS.[10,17,32,34–38] This study evaluated the use of a new self-etch conditioner with an RMGI in bonding brackets. The findings from this study indicated that the brackets bonded with this new conditioner and the RMGI Fuji Ortho LC had a mean SBS of 9.9 ± 4.1 MPa. This value was similar to the SBS of brackets bonded using Fuji Ortho LC with its recommended 10% polyacrylic acid conditioner (mean of 9.1 ± 4.6 MPa) as well as those bonded with a composite control, Transbond XT Plus (mean of 8.6 ± 2.6 MPa). It has been suggested that an SBS of 6.0 to 8.0 MPa is adequate for bonding orthodontic brackets to teeth.[43,44] The present findings indicate that all three groups tested in this study have reached this ideal range within the first half-hour following bonding. While earlier reports indicated that RMGIs have lower SBS than composite resins do,[32–36] especially in the first half-hour following bonding,[36] the present findings indicated that an RMGI used with either the new self-etch conditioner or the recommended conditioner provided a comparable SBS to that of the composite control. In addition, it was recently shown that following thermocycling, the SBSs of brackets bonded using an RMGI and a composite resin were not significantly different.[45]

The present results also indicated that the brackets bonded using Fuji Ortho LC failed in a different mode than those bonded using the Transbond adhesive system. In general, bond failure for brackets bonded using Fuji Ortho LC with either conditioner occurred at the enamel-adhesive interface, while brackets bonded using Transbond typically failed at the bracket-adhesive interface. Bracket failure at each of the two interfaces has its own advantages and disadvantages. As an example, bracket failure at the bracket-adhesive interface is advantageous since it leaves the enamel surface relatively intact. However, considerable chair time is needed to remove the residual adhesive, with the added possibility of damaging the enamel surface during the cleaning process.[46] On the other hand, when brackets fail at the enamel-adhesive interface, less residual adhesive remains, but the probability of damage to the enamel surface is increased when failure occurs in this mode.[47]

In summary, RMGIs provide the advantages of sustained fluoride release and can be used in a moist environment to bond brackets. In addition, the new self-etch conditioner tested offers the added benefit of not needing to be rinsed off following application. However, RMGIs need a longer curing time than most composite resin bonding systems do. The clinician should weigh the advantages and disadvantages of each bonding system when choosing an orthodontic bracket adhesive.

CONCLUSIONS

- Brackets bonded with the new self-conditioner had an SBS that was comparable to brackets bonded using both an RMGI with its recommended conditioner and brackets bonded with a composite resin.
- The new self-etch conditioner has the added benefit of not needing to be rinsed off and may reduce technique sensitively in the bonding process.

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