

Decalcification and bond failure: A comparison of a glass ionomer and a composite resin bonding system in vivo

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Decalcification during orthodontic treatment is a serious problem. A glass ionomer agent is now available to bond orthodontic brackets as an alternative to composite resins. This prospective study was a clinical trial to determine if a glass ionomer bonding system (Fuji Ortho LC) decreases the incidence of decalcification without increasing the amount of bonding failures. A prospective clinical trial with 16 patients encompassing a total of 298 teeth was conducted. The 149 control teeth were bonded with a light-cured composite resin (Reliance Light Bond) whereas the 149 experimental teeth were bonded with the light-cured glass ionomer agent. Patients were followed for a period of 12 to 14 months. All teeth were evaluated for breakage (bonding failure rate), and all maxillary anterior teeth (96) were evaluated for decalcification on a graded scale. The glass ionomer failure rate was 24.8%, and was higher than the composite resin failure rate of 7.4% ($P < .001$). There were more glass ionomer bond failures in 12 of 16 patients ($P < .001$). Enamel decalcification was similar in the 2 bonding systems. (Am J Orthod Dentofacial Orthop 1999;116:518-21)

The clinical effectiveness of Fuji Ortho LC, a light-cured, resin-reinforced glass ionomer was evaluated in its role as a bonding agent for orthodontic brackets. That product was compared with a traditional composite bonding agent on the basis of bond failure rate and the prevention of enamel decalcification.

BACKGROUND

The scope of orthodontic treatment has changed with the advent of composite resin-bonding materials. Previously, all teeth were individually banded, and these bands were then cemented with a luting agent, a very lengthy and uncomfortable procedure. With the use of composite bonding systems, smaller brackets that attached to the facial surfaces of the teeth replaced the need for banding and cementing all teeth. However, composite resins involve several highly technique-sensitive steps and require a completely dry operating field. In addition, an important orthodontic concern is decalcification of enamel around the bracket that often results in a permanent whitish discoloration.¹⁻⁴

Glass ionomer materials have become popular and accepted by the dental profession; they are being used as cavity liners, luting agents, sealants, and restorative materials. Only lately have glass ionomer agents been available for bonding orthodontic brackets. Recently, a new product, Fuji Ortho LC, has been developed to bond brackets to teeth. The manufacturer claims it can be applied in a wet field and is not as technique-sensitive as composite resins. Specifically, it requires no etching of the enamel surface and should be applied in a wet environment.

Another attribute of glass ionomers is that they release fluoride, which is known to reduce the incidence of caries.^{5,6} The process of fluoride release is by way of polyacid attack on the aluminosilicate glass. As the glass network breaks down the Al³⁺, Ca²⁺, and F⁻ ions are released.⁷ The capacity of glass ionomers to absorb fluoride from rinses and tooth paste in essence allows the glass ionomer to reconstitute itself and continuously release fluoride. This should aid in the decreased incidence of decalcification and unsightly white spots around the brackets.⁸⁻¹³ The advantages proposed to be gained by the operator and patient are substantial. Therefore, this study was planned to compare the new glass ionomer system to the standard composite resin in terms of bracket failure and decalcification. If all these factors were true of the new Fuji Ortho LC product, it clinically would be more beneficial than composite resin alone. Because of these possible improvements over composite resin, a test of Fuji Ortho LC effectiveness in lowering

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0889-5406/99/\$8.00 + 0 8/1/100623

Table 1. Comparison of decalcification rates for contralateral teeth

	Sample size		% Unchanged		% with decalcification		Significance P
	GI	Comp	GI	Comp	GI	Comp	
Canines	16	16	37.5	31.3	62.5	68.8	1.0
Lateral incisors	16	16	2.5	6.3	87.5	93.8	1.0
Central incisors	16	16	18.8	37.5	81.3	62.5	.25

GI, Fuji Ortho LC.
 Comp, Reliance Light Bond.

bracket failure rate and incidence of decalcification seemed in order.

MATERIAL AND METHODS

Sixteen patients from a teaching institution participated in this study. The patients were consecutively selected from individuals seeking orthodontic treatment at Albert Einstein Medical Center in Philadelphia. The maxillary and mandibular premolar, canine, and incisor teeth were bonded allowing up to 20 teeth per patient to be included in the study.

Using the universal tooth-numbering system of 1 to 32, the teeth were divided into 2 sets, one identified by even numbers and the other by odd numbers. The odd-numbered teeth were bonded with a traditional composite resin system (Reliance Light Bond, Fluoride-releasing, Reliance Orthodontic Products). The even-numbered teeth were be bonded with a glass ionomer system (Fuji Ortho LC glass ionomer cement, GC America Incorporated).

The manufacturer’s instructions were followed for each product. All teeth were cleaned with pumice (Moyco). The teeth with composite had the enamel surface etched with phosphoric acid and brackets applied in a completely dry field. The teeth with glass ionomer were not etched and brackets were applied in a wet field. This was accomplished by rinsing the teeth with water and leaving them wet.

Incidence of Decalcification

The 6 anterior maxillary teeth were evaluated for the incidence of decalcification. Each tooth was photographed preoperatively on a 1:1 magnification with a Nikon 6006 35 mm camera with a Lester Dine 105 mm macro lens and Kodachrome 64 slide film. A predetermined aperture setting with a standardized intraoral photography ring flash was used. If there was a bond failure, a new bracket was placed with the same bonding technique used on this tooth as before. Although this tooth was not considered further in computing bond failure rate, it was included in calculating the incidence of decalcification. The purpose of continuing

to assess rebonded teeth for decalcification was to model conventional clinical practice. At the end of 12 to 14 months, each maxillary anterior tooth was debonded and photographed with the exact procedure and identical camera as before. A comparison was made by a team of 7 dental professionals. They used a standardized rating system to determine the absence or degree of decalcification on the labial surface of each of the maxillary anterior teeth, both pretreatment and posttreatment. Decalcification was assessed and ranked as none, slight, or significant. Each tooth was assigned the median of the ranks given by the 7 evaluators. Using these median ranks before and after treatment, decalcification was classified as having worsened (or not) after treatment.

Bond Failure Occurrence

Every tooth bonded in the 16 subjects was used to assess the occurrence of bond failure. Once a tooth was bonded, any failure was noted. After failure, the tooth was no longer considered with respect to bond failure.

Statistics

Following the paired study design, all statistical comparisons between bonding methods were performed within contralateral pairs and within adjacent pairs. We compared decalcification in paired contralateral teeth and paired adjacent teeth receiving the 2 bonding agents using McNemar’s test. Specifically, which agent had a larger percentage of teeth with increased decalcification after treatment was assessed. Bond failure occurrence was compared using the Sign test for paired data. Statistical analyses were performed using SPSS for Windows 7.5 (Chicago, Ill).

RESULTS

Incidence of Decalcification

To determine the difference in incidence of decalcification between glass ionomer and composite resin, the 2 bonding methods were evaluated by examining the teeth both preoperatively and postoperatively. Of the 48 maxillary anterior teeth bonded with Fuji glass

Table II. Comparison of decalcification rates for adjacent teeth

	Sample size		% Unchanged		% with decalcification		Significance P
	GI	Comp	GI	Comp	GI	Comp	
Right canine/lateral	16	16	37.5	6.3	62.5	93.8	.125
Right central/lateral	16	16	18.8	6.3	81.3	93.8	.63
Left lateral/central	16	16	12.5	37.5	87.5	62.5	.22
Left/Lateral canine	16	16	12.5	31.3	87.5	68.8	.38

GI, Fuji Ortho LC.

Comp, Reliance Light Bond.

Table III. Bond failure rate

Material	Number of teeth	Number of failures	% Failures
Glass ionomer (Fuji Ortho LC)	149	37	24.8
Composite (Reference Light Bond)	149	11	7.4

ionomer, 37 (77.1%) teeth exhibited worse decalcification at the end of the study. Thirty-six of the 48 teeth (75%) bonded with composite exhibited worse decalcification at the end of the study.

Statistical comparisons between methods were done by pairing teeth into contralateral pairs (Table I) and adjacent pairs (Table II). Contralateral comparisons were of the opposite teeth, (eg, right and left maxillary canines), each receiving a different method. Adjacent comparisons (eg, right maxillary canine and right maxillary lateral incisor) allowed a regional assessment in the same manner. None of the 7 paired adjacent or contralateral differences between methods were statistically significant (all $P > .12$).

Bond Failure Occurrence

Sixteen patients participated in the prospective study to determine the difference in bond failure between glass ionomer and composite resin. Of the 149 posterior and anterior teeth bonded with Fuji glass ionomer, there were 37 bond failures (24.8%). There were 11 failures in the 149 teeth (7.4%) bonded with composite (Table III).

We statistically compared bonding methods by comparing the 12 anterior teeth for bond failure within patients; odd-numbered teeth were bonded by traditional composite resin and even-numbered teeth with the Fuji glass ionomer. In 12 of 16 patients, there were more failures in the 6 teeth bonded with Fuji than in the 6 teeth bonded with composite. With the Fuji system, 3 patients had no bond failures, 7 patients had one bond fail, 3 patients had 2 failures, 1 patient had 3 fail, and 2 patients had 4 bonding failures. For the brackets

bonded with composite, 11 patients had no bond failures and 5 patients had one fail. In summary, comparing the 2 systems, the number of bond failures was identical in 4 patients and higher in the remaining 12 patients when the Fuji system was used ($P < .001$).

DISCUSSION

The results of this study indicate that the bond strength of glass ionomer is not as strong as that of composite resin in clinical use. Our findings regarding bond strength were recently confirmed in 4 in vitro studies by Chung et al,¹⁴ Bishara et al,^{15,16} and Lippitz et al¹⁷. Fricker,¹⁸ in an in vivo study, showed no statistical difference between Fuji Ortho (chemically cured) and a composite bonding system (System 1+, Ormco Corporation). However Fuji Dentine Conditioner was applied before the application of Fuji Ortho adhesive. Fricker does state, "The bond strength of resin-modified glass ionomer is not as strong as composite resins, and they are not recommended in cases where there are occlusal interferences."

The manufacturer states that acid etching with phosphoric acid or conditioning with polycarboic acid before bonding is not necessary, and this is how the product was tested. It is possible that the bond strength of glass ionomer could be increased by etching or conditioning the enamel before bonding, which could reduce the bracket failure rate. However, this has not been clearly demonstrated clinically in the literature. Recently, Silverman and Cohen¹⁹ stated in the Readers' Forum of the AJO/DO that to reduce bond failures they have modified their use of Fuji Ortho LC by delaying arch wire insertion until 1 week after placing

brackets. This is contrary to the current recommendations of the manufacturer. In addition, there have been no in vivo studies to date to confirm their findings.

In our experience, the glass ionomer did *not* exhibit a lower incidence of decalcification than the composite resin. Despite the lack of acid etching in the Fuji Ortho LC, decalcification was similar in the 2 methods. Our findings are in contradiction to those of Vorhies et al,²⁰ who found smaller enamel lesions in teeth bonded with Fuji Ortho LC compared to a light-cured composite resin (Transbond XT, 3M/Unitek, Monrovia, Calif). However, their project was in vitro and of short duration (30 days).

Despite these findings, glass ionomers have several distinct advantages. They are easy to use, and the ability to work in a wet environment is a definite benefit. Bonding tubes on second molars is a case in point for ease of use. In addition, the clean-up at the debanding appointment was superb. The beneficial effect of a reduction in decalcification due to the use of glass ionomers was not seen in this study. This may be due to the fact that there is much less glass ionomer under an orthodontic bracket compared with an orthodontic band. Therefore, with less glass ionomer present, there is probably less fluoride being released. Glass ionomer bonding agents certainly have a place in orthodontics today and should not be readily dismissed.

SUMMARY AND CONCLUSIONS

A prospective clinical study comparing glass ionomer and composite resin bonding agents was performed. Substantially more bond failures occurred with the glass ionomer (24.8%) than with the composite resin bonding system (7.4%). There were more glass ionomer bond failures in 12 of 16 patients. The glass ionomer system was used without etching or conditioning the enamel following the manufacturer's recommended procedure for use. Further in vivo study of glass ionomer bonding with enamel conditioning appears to be indicated. When the 96 teeth in the study were examined for decalcification, 37 of 48 (77%) of the glass ionomer teeth exhibited some

degree of decalcification as compared to 36 of 48 (75%) teeth that exhibited decalcification with the composite resin. We found no statistical difference in the incidence of decalcification between the 2 methods. Further study of other factors, products, and techniques are needed.

We thank Dr Charles Gemmi III, orthodontic resident, for his assistance and support with the preparation of this manuscript.

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