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SCIENTIFIC SECTION

The effect of pumicing on the *in vivo* use of a resin modified glass poly(alkenoate) cement and a conventional no-mix composite for bonding orthodontic brackets

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Abstract

Objective Pumicing of the enamel prior to direct bonding with conventional diacrylate bonding agents has been shown to be unnecessary. It is not known whether this is also the case with resin-modified glass poly(alkenoate) cements. The aims of this study were two-fold: (a) to determine whether pumicing prior to bonding has an effect on the *in vivo* failure of brackets bonded with either Right-On or Fuji II LC; (b) to determine whether there is a difference in the *in vivo* failure of brackets bonded with either Right-On or Fuji II LC.

Design A cross-mouth controlled clinical trial was performed on a total of 60 patients in which the variables under test were pumicing or not pumicing of the enamel prior to bonding using two different bonding agents.

Main outcome measures The measurement variable was bond failure over an 18-month period.

Results and conclusions Prior pumicing of the enamel has no effect on *in vivo* failure when using either a conventional diacrylate or a resin modified glass poly(alkenoate) cement. A greater number of bonds failed with the resin-modified glass poly(alkenoate) cement.

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Introduction

Diacrylate bonding agents have been successfully used as orthodontic bonding agents for many years. They rely on mechanical adhesion to the enamel surface, which requires enamel pretreatment with orthophosphoric acid prior to bracket placement. Stated disadvantages of diacrylate adhesives for orthodontic bonding include: enamel loss prior to treatment as a result of acid etching,[1] an inability to maintain a sustained level of fluoride release able to reduce the risk of in treatment decalcification,[2] and enamel loss at debond and subsequent clean up.[3] In 1990 Cook described the use of glass poly-(alkenoate) cement for the direct bonding of brackets to anterior teeth.[4] Advantages of their use for this purpose include no need for prior acid etching of the enamel, fluoride release, and consequently less decalcification during treatment.[5] However, conventional glass poly-(alkenoate) cements have been found to have unacceptably high bond failure rates in clinical practice, ranging from 12.4 per cent[6] up to as high as 50 per cent.[7] More recently, resin-modified glass poly(alkenoate) cements have been introduced for use in orthodontic bonding. Comprising the conventional acid-base reaction between the acidic polymer and basic glass there is the additional presence of a polymerizable resin, usually HEMA. Silverman *et al.* describe the use of such a material for direct bonding and found a relatively low bond failure rate of only 3.2 per cent after 8 months.[8] This is all the more impressive when teeth as far back as the second permanent molars were bonded. More recently, a 12-month study involving a cross-mouth control on incisor and

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cuspid teeth found a 5 per cent bond failure rate for the resin modified glass poly(alkenoate) compared to 8.3 per cent for a composite.[9] In both studies the enamel surface was polished with a slurry of pumice in water. In the latter study, it was then conditioned with a 10 per cent solution of poly(acrylic acid) prior to bonding with the resin-modified glass poly(alkenoate) cement. In the former study, no such conditioning was performed after pumicing. Previous work on pumicing as a surface pre-treatment prior to the use of conventional composite resin and the acid etch technique, has shown it to have no effect on observed bond failure rates.[10,11] What is unknown is whether pumicing and poly(acrylic acid) conditioning of the enamel surface are necessary when the resin-modified glass poly(alkenoate) cements are used as orthodontic bonding agents. In the present study, the following null hypotheses were tested in two separate experiments:

- Pumicing prior to bonding has no effect on the *in vivo* failure of brackets bonded with either Right-On or Fuji II LC (Experiment 1).
- There is no difference in the *in vivo* failure of brackets bonded with either Right-On or Fuji II LC (Experiment 2).

Materials and methods

Sixty consecutive patients attending for fixed appliance treatment had 'A' Company 0.022-inch Minitwin brackets bonded to their teeth. Molar bands and archwires were fitted at the same sitting and by one operator. The initial archwire sequence in each case consisted of 0.012-inch nickel titanium followed by 0.016-inch nickel titanium. The adhesives under test were the no-mix material Right-On (TP Orthodontics La Porte Ind., USA) and the resin-modified glass poly(alkenoate) Fuji II LC (GC Corp. Tokyo, Japan). In each case, the materials were used in accordance with the manufacturer's instructions. The enamel pretreatment in the case of the no-mix adhesive group included:

- acid etching with 37 per cent orthophosphoric acid for 30 seconds;
- washing with copious amounts of water;
- thorough drying with oil free compressed air;
- primer was placed onto both the etched enamel surface and the bracket base;
- filled diacrylate paste was then put onto the primed base and the bracket seated onto the tooth;
- excess adhesive was then removed from the periphery and the bracket left undisturbed for a minimum of 10 minutes before the archwires were fitted.

No acid conditioning was performed prior to bonding with Fuji II LC. The bonding procedure was as follows:

- Powder and liquid were mixed according to the manufacturers instructions in the proportion of 1 level scoop of powder to 2 drops of liquid.
- This was then placed on the bracket base and the bracket positioned on the tooth.
- Excess adhesive was removed from the periphery and care was taken to ensure the enamel surface remained moist prior to and during bracket placement.
- The adhesive was cured using a light-curing unit (Ortholux, 3M, Minnesota, USA) with a time of 20 seconds per inter-space.

Each patient formed their own cross-mouth study, with the mouth being divided into quadrants and the quadrants consecutively allocated a particular enamel pretreatment or adhesive. The patients were divided into three groups as follows:

- *Group 1 (20 patients):* all brackets bonded with no-mix bonding agent. The variable under test was the enamel pre-treatment, pumicing or no pumicing prior to bonding.
- *Group 2 (20 patients):* all brackets bonded with the resin-modified glass poly(alkenoate) cement. The variable under test was the enamel pretreatment with or without pumicing prior to bonding.
- *Group 3 (20 patients):* the enamel in each case was pumiced. Brackets were bonded either with the no-mix bonding agent after etching or with the resin-modified glass poly(alkenoate) cement without etching.

Prior to the start of this study ethical committee approval was granted. The outcome variable was the success or failure of the bond after 18 months. When a bracket was rebonded after failure, a fresh bracket was used and was bonded with the no-mix bonding agent.

A total of 649 bonds were placed in experiment 1 (groups 1 and 2) and a total of 317 bonds were placed in experiment 2 (group 3).

Results and data analysis

The experimental variable of interest was the number of bonds surviving intact at the end of the 18-month observation period. Since this is censored survival data the groups were compared using the log-rank test.[12] In addition, the odds ratio and associated 95 per cent con-

Table 1 Status of bonds at the end of the 18-month test period as a function of material, pumice, and patient's sex (experiment 1)

Material	Fuji				Right On			
Sex	M		F		M		F	
Outcome	F	S	F	S	F	S	F	S
No pumice	17	26	36	80	3	27	28	117
Pumice	13	30	24	85	4	24	22	113
P	0.08				0.67			
OR	1.37 (0.96–1.96)				1.11 (0.69–1.78)			

Legend. Sex: M, male; F, female. Outcome: F, failed; S, success. *P*, probability associated with the log-rank test comparing the effect of pumice within material. OR, odds ratio (no pumice:pumice) and associated 95 per cent confidence interval.

Table 2 Status of bonds at the end of the 18-month test period as a function of material and patient's sex (Experiment 2)

Material	Fuji				Right On			
Sex	M		F		M		F	
Outcome	F	S	F	S	F	S	F	S
	14	27	29	90	4	36	16	101
P	0.01							
OR	2.11 (1.31 to 3.42)							

Legend. Sex: M, male; F, female. Outcome: F, failed; S, success. *P*, probability associated with the log-rank test comparing materials. OR, odds ratio (Fuji:Right On) and associated 95 per cent confidence interval.

fidence interval for the two test groups was also calculated.[13] Data was analysed using Stata 7 (StataCorp 2001, Stata Statistical Software: Release 7.0, College Station, TX: Stata Corporation) and significance was predetermined at $\alpha = 0.05$. The data is summarized in Tables 1 and 2 for experiments 1 and 2, respectively. Preliminary analysis showed there to be no effect of sex, thus data was pooled over sex.

From experiment 1 there was no effect of pumicing on bond failure for either Fuji, $P = 0.08$ and odds ratio (no pumice:pumice) = 1.37, or Right On, $P = 0.67$ and odds ratio = 1.11. There was a significant difference in bond failure between Fuji and Right On, experiment 2, $P = 0.01$, odds ratio (Fuji:Right On) = 2.11.

Discussion

Previous work studying the *in vivo* effect of enamel pumicing prior to acid etching and bonding with a diacrylate adhesive[10,11] has shown it to have little effect on clinical bond failure rates. This current work confirms this finding for the diacrylate under test, but it also demonstrates that pumicing has no significant effect on the *in vivo* failure proportion of brackets bonded with the resin-modified glass poly(alkenoate) cement Fuji II LC (Table 1). In none of the patients in this study was the enamel preconditioned prior to the use of Fuji II LC, either with the poly(acrylic acid) conditioner supplied with Fuji II LC or with orthophosphoric. The precise mechanism of adhesion between the resin-modified glass poly(alkenaoate) cement and the enamel is unknown. It has been proposed that carboxylate groups in glass poly(alkenoate) cements chelate calcium ions in hydroxyapatite,[14] or alternatively that poly(acrylate) metal bonds are ionic in nature between the carboxylate groups of the cement and the enamel surface.[15] Wilson *et al.* supported the ionic bonding theory and found that ion exchange occurred at the surface of hydroxyapatite.[16] Calcium and phosphate ions are displaced from the hydroxyapatite surface as the poly(acrylic) chains of the cement become embedded in its surface. An intermediate layer may therefore be formed between the bulk of the enamel and the bulk of the cement. This layer consists of enamel with embedded poly(acrylate) and glass ionomer cement, which is rich in calcium and phosphate ions from the enamel surface. For such ion exchange to occur it might be expected that an uncontaminated enamel surface would be desirable. The finding that pumicing the enamel has no significant effect on *in vivo* bond failure is therefore surprising. Certainly Silverman *et al.* reported a low 3.2 per cent *in vivo* bond failure rate over an 8-month period using the same resin-modified glass poly(alkenoate) Fuji II LC as in this clinical investigation.[8] Although no acid conditioning was used, the enamel was pumiced prior to bonding, presumably to remove any plaque and pellicle. However, other investigators using the same enamel treatment regimen, but with Fuji Ortho LC, observed a much greater bond failure rate of 24.8 per cent.[17] In this latter work the bond failure rate for the light cured diacrylate control was also quite high at 7.4 per cent. In view of the widely differing reported bond failure rates it would seem that bond failures when using resin-modified glass poly(alkenoate) cements are perhaps effected by other, more important factors than the enamel surface treatment prior to bonding. These might include the powder to liquid ratio during mixing,[17] the presence or absence of moisture on the enamel surface or perhaps the interaction between the bonding agent and the bracket base.[18]

The finding that the number of bond failures for the resin-modified glass poly(alkenoate) cement were higher than for the diacrylate (Table 2) supports the finding of other workers.[18,19] Whether this increased bond failure, which seems to vary greatly between different operators, is acceptable is open to question.

Conclusions

Under the conditions of this experiment the following conclusions were reached:

- Pumicing of the enamel prior to the use of both the resin-modified glass poly(alkenoate) cement Fuji II LC and the no-mix diacrylate Right-On had no effect on observed *in vivo* failure.
- There was a significantly greater number of bond failures observed with the resin-modified glass poly-(alkenoate) cement Fuji II LC than with no-mix diacrylate Right-On over the 18-month experimental period.

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