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Enamel loss at bond-up, debond and clean-up following the use of a conventional light-cured composite and a resin-modified glass polyalkenoate cement

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SUMMARY The aim of this study was to determine whether there was any difference in the degree of enamel loss at bond-up, debond and enamel clean-up when two different adhesive systems were tested and with four different methods of enamel clean-up. The adhesive systems were 37 per cent *o*-phosphoric acid with Transbond XT (group 1) and 10 per cent poly(acrylic acid) conditioner with Fuji Ortho LC (group 2). Using flattened enamel specimens, enamel loss at each stage was determined using a planer surfometer. These stages were: prior to treatment, at pumice prophylaxis, following enamel etching or conditioning and following enamel clean-up. The four clean-up methods were a high-speed tungsten carbide bur, a slow-speed tungsten carbide bur, an ultrasonic scaler and debanding pliers.

The results, analysed using non-parametric tests, demonstrated that significantly more enamel loss occurred following the use of 37 per cent *o*-phosphoric acid than poly(acrylic acid) conditioner ($P = 0.001$). At debond and prior to clean-up, more adhesive remained on the enamel surface in group 1 than in group 2 ($P = 0.005$). During the subsequent enamel clean-up and with both adhesive systems, the least enamel loss occurred following the use of the slow-speed tungsten carbide bur and the greatest loss was seen with the ultrasonic scaler or high-speed tungsten carbide bur.

Overall, the lowest enamel loss was observed with the poly(acrylic acid) conditioner and Fuji Ortho LC system (group 2) and where enamel clean-up was performed using the slow-speed tungsten carbide bur.

Introduction

In recent years, resin-modified glass polyalkenoate cements have been used as orthodontic bonding agents. A significant stated advantage in their use as orthodontic bonding agents is their ability not only to release fluoride in their own right (McNeill *et al.*, 2001), but also to act as a rechargeable fluoride reservoir (Ashcraft *et al.*, 1997; Benington *et al.*, 2001), hereby reducing the likelihood of enamel decalcification during treatment (Underwood *et al.*, 1989). The results of *in vitro* bond tests in which the force to debond has been compared with that of conventional diacrylate adhesives have been somewhat equivocal. In some cases, the measured force to debond resin-modified glass polyalkenoate cements has been found to be significantly lower than with conventional diacrylate bonding agents (Shammaa *et al.*, 1999; Rix *et al.*, 2001), while in others cases no such difference was observed (Choo *et al.*, 2001a). The true test of their ability to act as orthodontic bonding agents is their *in vivo* performance. In an 8 month study exclusively using a resin-modified glass polyalkenoate cement in which the enamel was not pumiced and where bonds were placed as far back in the mouth as the second molars, a very low bond failure rate of only 3.4 per cent was reported (Silverman *et al.*, 1995). In a later prospective randomized cross-mouth controlled trial, where the enamel was both pumiced and treated with 10 per cent poly(acrylic acid) conditioner for 10–20 seconds per tooth, as recommended by the manufacturer, the bond failure rate over a 12 month period was only 5.8 per cent for the resin-modified glass polyalkenoate cement, compared with 7.2 per cent for the control material of a light-cured diacrylate (Choo *et al.*, 2001b). Resin-modified glass polyalkenoate cements therefore perform as well, if not better, than conventional orthodontic bonding agents. Another possible advantage of the use of resin-modified glass polyalkenoate cements is reduced enamel loss following orthodontic treatment. The use of a poly(acrylic acid) conditioner prior to their use is similar in principle to crystal growth using the same conditioner prior to the use of diacrylate adhesives (Read *et al.*, 1986). To-date enamel loss following their use has not been quantified. Previous work has reported enamel loss at each stage of the bonding and debonding process. Enamel loss at the pumicing stage can vary from 5 to 6.9 μm (Pus and Way, 1980; Thompson and Way, 1981) acid etching with 37 per cent *o*-phosphoric acid can lead to a loss of between 4 μm (Silverstone, 1974) and 170 μm (Diedrich, 1981), whereas the loss at enamel clean-up can be between 55.6 μm (Fitzpatrick and Way, 1977) and 149.87 μm (standard deviation 202.18) (Krell *et al.*, 1993) dependent to a large degree on the method of adhesive removal.

The aim of this study was, therefore, to examine enamel loss at each stage of the bonding, debonding and enamel clean-up process following the use of a resin-modified glass polyalkenoate cement, and to compare this with measured enamel loss following the use of conventional acid etching and a light-cured filled diacrylate bonding agent.

Materials and method

Eighty human upper premolar teeth extracted for orthodontic purposes were used in this study. Each tooth had the root removed and the crown sectioned into two. The buccal aspect of the crown was then embedded in cold-cure acrylic, using a polyvinyl siloxane mould, to form a mounting jig measuring 30 × 30 × 2.5 mm. A sectioned crown was placed in the centre of each mould with the buccal surface touching the base. Once set, each mounting jig was then levelled using 350 grit silicon carbide polishing discs on a grinding wheel so that it would lay flat on the work bench. Excess acrylic was then carefully ground from around the specimen until an area of enamel 4 × 4mm in size was exposed (Figure 1). One thousand and then 1200 grit silicon carbide discs were used in succession until the enamel surface was polished and levelled to $0 \leq 0.30$ µm, as measured on a surfometer (Planer industrial surfometer, Sunbury-on-Thames, Middlesex, UK). Each sample, once levelled, was measured twice using the surfometer and these served as the baseline untreated enamel levels. The scanning stylus of the surfometer measures 20 µm in diameter and scans each specimen at a speed of 10 mm/minute and to a resolution of 0.01 µm.

The untreated samples were divided randomly into two equal groups: group 1: Transbond™ XT (3M Unitek, St Paul, Minnesota, USA) and 37 per cent *o*- phosphoric acid; group 2: Fuji Ortho LC (GC Corp., Tokyo, Japan) and 10 per cent poly(acrylic acid) conditioner (GC Corp.).

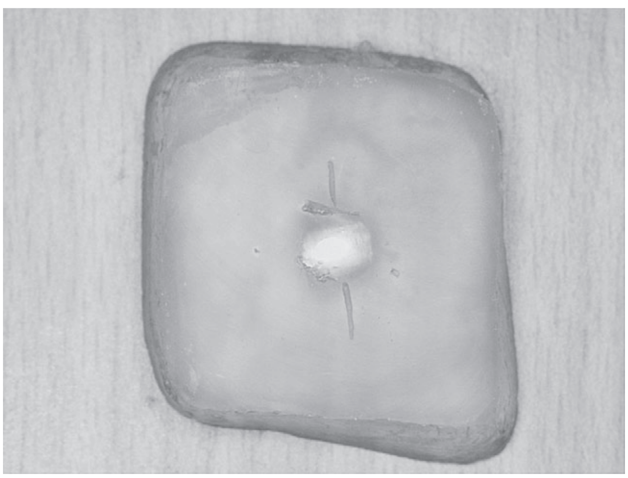

Figure 1 A flattened enamel specimen embedded in the acrylic mounting block.

For each specimen in each group a small area of enamel was taped off using PVC tape (Instromark Tape, Henleys Medical, Welwyn Garden City, UK) at either end (i.e. occlusally and gingivally) in order to preserve untreated enamel, which would act as a reference for the duration of the experiment. The area of enamel left untaped was sufficiently large to enable a lower incisor bracket to be bonded. Each sample was pre-treated with a slurry of pumice and water in a rubber cup using a slow-speed handpiece for 20 seconds, followed by washing with water from a 3-in-1 syringe and then air drying using oil-free compressed air. The tape was then removed and the enamel loss of each sample was measured twice on the surfometer.

In group 1 the specimens were retaped and the enamel that remained exposed was then etched using 37 per cent *o*-phosphoric acid for 15 seconds, washed with copious amounts of water and then dried with oil-free compressed air until frosty white in appearance. The tapes were again removed and enamel loss measured twice using the surfometer. Once the tapes had been replaced, the etched surfaces were then primed with Transbond™ XT primer and a short burst of air blown onto the surfaces. Filled Transbond™ resin was applied onto the lower incisor bracket base (Mini-Twin Siamese Brackets, 3M Unitek) for each specimen and the bracket pressed firmly, using a Mitchell's trimmer, onto the prepared enamel. Excess resin was removed from around the bracket margins with a probe and light cured for 10 seconds mesially and distally (20 seconds per tooth).

In group 2 the untaped enamel surfaces of 40 pumiced samples were taped and treated with 10 per cent poly(acrylic acid) conditioner for 20 seconds, according to the manufacturer's instructions. These were then rinsed with copious amounts of water and dried with oil-free compressed air. Enamel loss was measured as before at this point following tape removal. The specimens were then retaped and moistened with water from the 3-in-1 syringe. Fuji Ortho LC was then mixed according to the manufacturer's instructions and placed onto the bracket base. The bracket was firmly applied to the enamel specimen in each case. Excess adhesive was removed from around the periphery of the brackets before light curing for 40 seconds per tooth (20 seconds mesially and 20 seconds distally).

In both groups the lower incisor brackets were allowed to bench cure for 1 hour before being debonded using debonding pliers. Residual adhesive remaining on the enamel surface was then scored using the Adhesive Remnant Index (ARI; Årtun and Bergland, 1984). In each of the two groups, the 40 specimens were then divided randomly into four further groups of 10 specimens and these were then subjected to one of four clean-up methods:

Batch 1: adhesive removed with a spiral fluted tungsten carbide debonding bur in a high-speed handpiece (#118 S bur, Forestadent, Pforzheim, Germany);

Batch 2: adhesive removed with a spiral fluted tungsten carbide bur (1172RA, Ortho Care UK Ltd, Bradford, UK) and a slow-speed handpiece;
Batch 3: adhesive removed with an ultrasonic scaler (Dentsply Cavitron SPS, Konstanz, Germany);
Batch 4: adhesive removed with debanding pliers.

Enamel loss was then recorded following adhesive removal in each case.

Results

The results were analysed using Stata version 8 (StataCorp LP, Texas, USA) with significance predetermined at $\alpha = 0.05$. Summary statistics of the enamel loss at each of the stages of the bonding/debonding and enamel clean-up process are shown in Table 1. The data were tested for normality using the Shapiro–Wilk test and were found to be distributed in a manner indicating that non-parametric analyses were appropriate. In all cases the significance level was predetermined at $\alpha = 0.05$. To test the reproducibility of the testing method, the paired data measurements of the untreated enamel specimens were analysed using the Bland–Altman test for assessing agreement (Table 2) (Bland and Altman, 1986). Agreement was also assessed using Lin's concordance (Lin, 1989) (Table 2) and two examples are illustrated in Figure 2. Both methods showed fair to good agreement on these baseline specimens, with the greatest range of differences being –0.03 to 0.295 µm.

A Mann–Whitney test was performed to determine whether there was a difference in enamel heights in the untreated state (P = 0.085) and then again following pumicing (P = 0.156) (Table 3). In each case there was no difference between the two groups. When the enamel

Table 1 Summary statistics of enamel loss. Negative mean and median values represent enamel loss and positive values surface height gain.

Code	Number	Mean (µm)	Median (µm)	SD	Interquartile range	Minimum (µm)	Maximum (µm)	95 per cent confidence interval	Shapiro–Wilk P
1	10	0.12	0.10	0.07	0.07 to 0.18	0.02	0.27	0.09 to 0.16	0.230
2	10	0.18	0.18	0.11	0.16 to 0.27	–0.16	0.30	0.13 to 0.23	0.001
3	10	0.09	0.10	0.08	0.04 to 0.13	–0.07	0.27	0.05 to 0.13	0.886
4	10	0.10	0.11	0.07	0.07 to 0.14	–0.05	0.22	0.07 to 0.13	0.880
5	10	0.12	0.07	0.10	0.03 to 0.21	–0.02	0.27	0.07 to 0.16	0.017
6	10	0.14	0.13	0.11	0.08 to 0.24	–0.15	0.28	0.09 to 0.19	0.029
7	10	0.14	0.16	0.13	0.01 to 0.26	–0.05	0.30	0.08 to 0.21	0.029
8	10	0.20	0.21	0.06	0.18 to 0.24	0.08	0.30	0.17 to 0.23	0.755
9	10	–0.43	–0.37	0.90	–1.06 to 0.10	–2.38	1.07	–0.85 to –0.01	0.976
10	10	–0.28	0.24	1.30	–0.07 to 0.33	–3.78	0.58	–0.90 to 0.34	0.001
11	10	–0.05	–0.05	0.21	–0.19 to 0.10	–0.42	0.32	–0.15 to 0.04	0.559
12	10	–0.02	0.07	0.47	–0.27 to 0.31	–1.16	0.74	–0.24 to 0.20	0.509
13	10	0.01	0.07	0.22	–0.10 to 0.11	–0.46	0.37	–0.10 to 0.11	0.436
14	10	0.21	0.19	0.29	0.05 to 0.30	–0.27	0.94	0.08 to 0.35	0.570
15	10	–0.11	–0.04	0.40	–0.31 to 0.18	–0.84	0.60	–0.30 to 0.08	0.181
16	10	0.03	0.11	0.32	–0.08 to 0.25	–0.82	0.44	–0.12 to 0.18	0.045
17	10	–2.69	–2.78	0.74	–3.27 to –2.08	–3.84	–1.53	–3.04 to –2.34	0.319
18	10	–3.08	–3.38	0.99	–3.79 to –2.12	–4.49	–1.20	–3.55 to –2.61	0.127
19	10	–2.01	–1.90	0.66	–2.38 to –1.51	–3.42	–1.11	–2.32 to –1.70	0.198
20	10	–3.02	–2.85	0.71	–3.48 to –2.53	–4.57	–1.89	–3.35 to –2.68	0.707
21	10	0.02	0.04	0.33	–0.23 to 0.30	–0.57	0.49	–0.14 to 0.17	0.184
22	10	0.02	0.02	0.17	–0.10 to 0.16	–0.43	0.27	–0.06 to 0.09	0.263
23	10	–0.30	–0.09	0.75	–0.59 to 0.11	–2.99	0.41	–0.66 to 0.06	0.001
24	10	0.04	0.18	0.33	–0.23 to 0.29	–0.62	0.53	–0.12 to 0.20	0.126
25	10	–10.72	–6.43	9.93	–19.41 to –2.33	–28.74	2.12	–15.37 to –6.08	0.010
26	10	–3.02	–3.12	1.11	–3.84 to –2.43	–4.43	–0.05	–3.54 to –2.50	0.162
27	10	–13.55	–14.30	9.18	–18.97 to –5.06	–31.41	–1.27	–17.85 to –9.26	0.175
28	10	–0.88	–1.58	3.11	–2.91 to 0.08	–3.67	7.80	–2.34 to 0.57	0.001
29	10	–3.91	–1.87	4.93	–3.40 to –1.19	–15.15	0.83	–6.21 to –1.60	0.001
30	10	0.33	0.37	0.37	0.09 to 0.64	–0.42	0.75	0.16 to 0.50	0.100
31	10	–5.60	–5.55	5.83	–10.19 to –0.86	–16.94	5.19	–8.33 to –2.88	0.646
32	10	0.84	0.56	0.92	0.16 to 1.23	–0.48	3.22	0.41 to 1.27	0.043

SD, standard deviation.
Codes 1–4, untreated enamel + group 1 (37 per cent *o*-phosphoric acid group); codes 5–8, untreated enamel + group 2 [10 per cent poly(acrylic acid) group]; codes 9–12, enamel treated with pumice and rubber cup + group 1; codes 13–16, enamel treated with pumice and rubber cup + group 2; codes 17–20, enamel etched with 37 per cent *o*-phosphoric acid + group 1; codes 21–24, enamel etched with 10 per cent poly(acrylic acid) + group 2; code 25, group 1 + adhesive removed with high-speed bur; code 26, group 1 + adhesive removed with slow-speed bur; code 27, group 1 + adhesive removed with ultrasonic scaler; code 28, group 1 + adhesive removed with debanding pliers; code 29, group 2 + adhesive removed with high-speed bur; code 30, group 2 + adhesive removed with slow-speed bur; code 31, group 2 + adhesive removed with ultrasonic scaler; code 32, group 2 + adhesive removed with debanding pliers.

Table 2 Results of the Bland–Altman test for assessing agreement for the untreated specimens (for codes see Table 1) along with Lin's concordance correlation coefficient.

Code	Limits of agreement	Mean difference	95 per cent confidence interval	Range	Lin's concordance
1	–0.221 to 0.191	–0.015	–0.089 to 0.059	0.045 to 0.195	0.07
2	–0.266 to 0.294	0.014	–0.086 to 0.114	0.01 to 0.29	0.203
3	–0.246 to 0.16	–0.043	–0.116 to 0.03	–0.045 to 0.155	0.215
4	–0.134 to 0.14	0.003	–0.046 to 0.052	–0.035 to 0.175	0.540
5	–0.194 to 0.142	–0.026	–0.086 to 0.034	–0.005 to 0.265	0.659
6	–0.276 to 0.27	–0.003	–0.101 to 0.095	–0.015 to 0.28	0.247
7	–0.16 to 0.13	–0.015	–0.067 to 0.037	–0.03 to 0.295	0.853
8	–0.102 to 0.212	0.055	–0.001 to 0.111	0.115 to 0.265	0.098

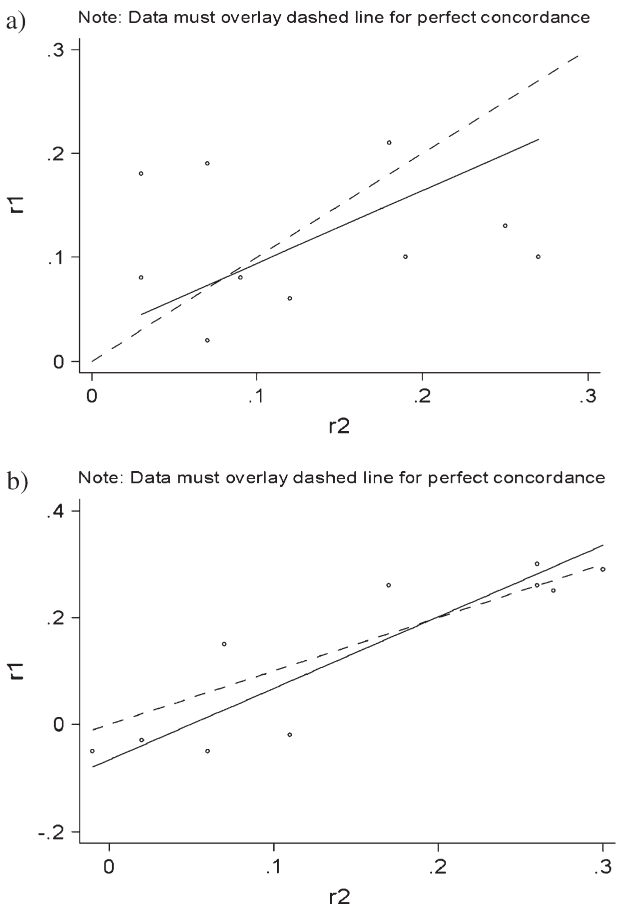

Figure 2 Lin's concordance plots for (a) code 1 and (b) code 7 untreated specimens showing fair and excellent concordance, respectively.

surface heights were compared after conventional acid etching (group 1) and the use of poly(acrylic acid) conditioner (group 2), there was found to be a statistically significant difference between the two groups (P = 0.001; Table 3). Following bracket removal, the ARI scores were compared and once again there was found to be a significant difference between the two treatment groups (P = 0.005; Table 3). More adhesive/bracket interface failures occurred in the 37 per cent *o*-phosphoric acid etch/Transbond XT group, meaning that more of the adhesive remained on the enamel surface at debond than in the Fuji Ortho LC group.

Table 3 Comparison of the Transbond XT (conventional etch) and Fuji Ortho LC (conditioner) groups under various conditions.

Variable	Condition	Number	P*
Enamel height	Untreated enamel	40	0.085
Enamel height	Pumiced enamel	40	0.158
Enamel height	Etched/conditioned	40	0.001
ARI		40	0.005

ARI, Adhesive Remnant Index.
*Mann–Whitney test.

The total surface enamel loss in each of the two main treatment groups following adhesive removal was analysed using a Bonferroni multiple comparison of all possible pairwise combinations for the clean-up techniques. These are shown as smile plots in Figure 3 (Newson, 2003). In a smile plot, the P-values are plotted on the y-axis using a reverse log scale, and in this case the x-axis is the z-value associated with the pairwise test. The upper line is known as the parapet line and is the Bonferroni corrected probability. Values above this line are statistically significantly different.

In both groups, the greatest degree of enamel loss occurred with the use of the ultrasonic scaler and least with either the slow-speed tungsten carbide bur or the debanding pliers. Finally, using the Mann–Whitney test, enamel loss in each of the four clean-up methods was compared across the two main treatment groups (Table 4). In all cases the total enamel loss following clean-up was greater in the 37 per cent *o*-phosphoric acid etch/Transbond XT group (group 1) than in the poly(acrylic acid) conditioner/Fuji Ortho LC group (group 2).

Discussion

Prior to any enamel treatment, but also after pumicing of the enamel with a rubber cup and a slurry of pumice in water, there was no statistical difference between the

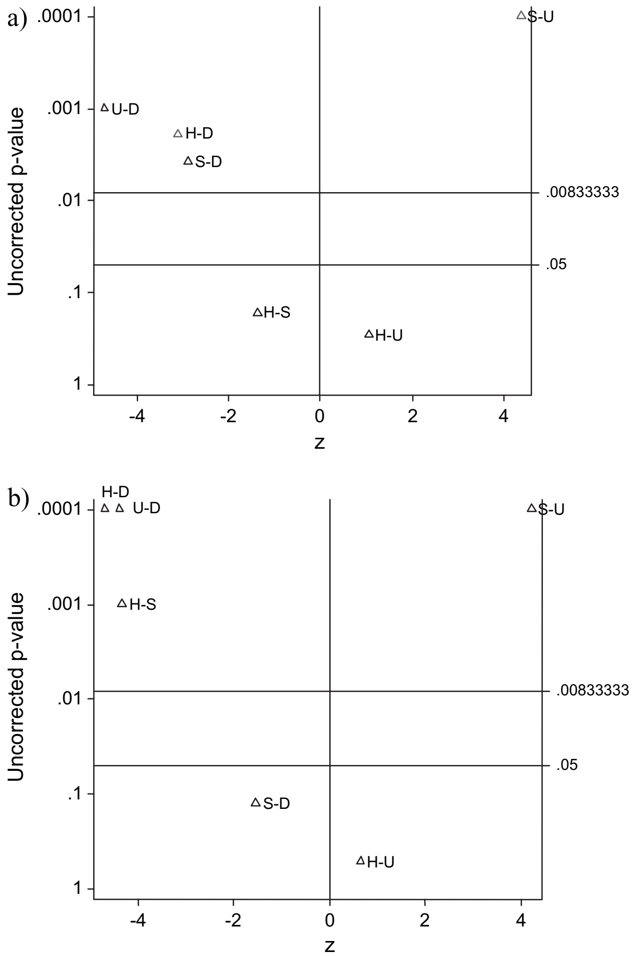

Figure 3 Smile plots for the pairwise comparison of total enamel loss following the four clean-up techniques for (a) Transbond XT (conventional etch) and (b) Fuji Ortho LC (conditioner). H–S, high-speed bur versus slow-speed bur; H–D, high-speed bur versus debanding pliers; H–U, high-speed bur versus ultrasonic scaler; S–D, slow-speed bur versus debanding pliers; S–U, slow-speed bur versus ultrasonic scaler; U–D, ultrasonic scaler versus debanding pliers.

Table 4 Comparison of total enamel loss between Transbond XT (conventional etch) and Fuji Ortho LC (conditioner) as a function of clean-up technique.

Technique	Number	*P**
High-speed bur	10	0.010
Slow-speed bur	10	0.001
Debanding pliers	10	0.001
Ultrasonic scaler	10	0.006

*Mann–Whitney test.

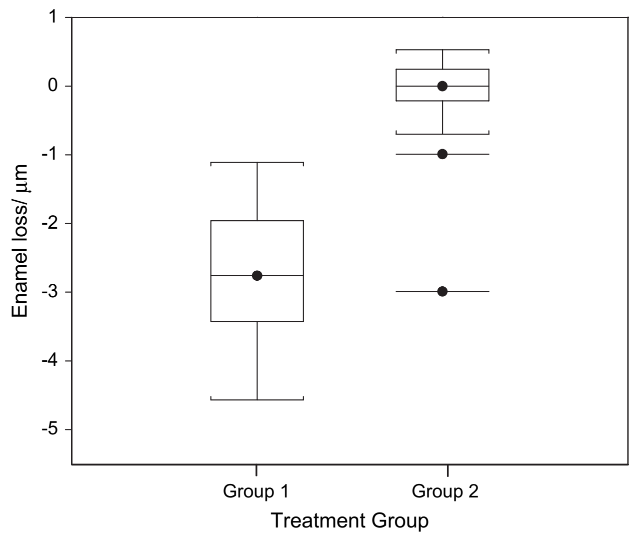

Figure 4 A box and whisker plot showing median enamel surface height, interquartile range, and maximum and minimum (µm) after conventional acid etching (group 1) and use of the poly(acrylic acid) conditioner (group 2).

enamel heights in groups 1 and 2 (Table 3). Enamel loss following pumicing ranged from 1.07 to –3.78 µm, with the positive value probably being as a result of residual pumice remaining on the enamel surface following rinsing.

Pumicing prior to conventional etching and the use of a filled diacrylate bonding agent has been shown to be unnecessary (Barry, 1995), as it has prior to the use of a resin-modified glass polyalkenoate cement (Ireland and Sherriff, 2002) and its omission could therefore lead to an enamel saving of up to –3.78 µm.

Following pumicing, the specimens in group 1 underwent conventional etching with 37 per cent *o*-phosphoric acid, while those in group 2 were conditioned with the poly(acrylic acid) supplied with the resin-modified glass polyalkenoate cement. The observed change in enamel height between the two groups was statistically significant (Table 3, Figure 4).

After conventional etching, the enamel loss ranged from –1.11 to –4.57 µm, whereas following treatment with poly(acrylic acid) this loss ranged from 0.53 to –2.99 µm. Previous studies examining conventional etching have reported surface losses of enamel ranging from 4 µm (Silverstone, 1974) up to 170 µm (Diedrich, 1981) and so the surface losses in the present experiment are very low in comparison. With the group 2 specimens, the range of enamel loss demonstrated that for some specimens there was still a net gain in enamel surface height. This may have been due to residual pumice still being on the surface or to gypsum crystal growth. Poly(acrylic acid) has been used to stimulate such crystal growth on the enamel surface in order to try to minimize enamel loss, although the measured force to debond was so low as to preclude its clinical use for direct bonding with diacrylate adhesives (Smith and Cartz, 1974; Read *et al.*, 1986). Although enamel loss following poly(acrylic acid) pre-treatment was found to be minimal, it is possible to use resin-modified glass polyalkenoate cements without such acid conditioning, thereby perhaps reducing enamel loss even further (Silverman *et al.*, 1995). However, it may lead to an increase in the number of in-service bond failures (Ireland and Sherriff, 2002)

In the next stage of the experiment, the brackets were bonded and then debonded and the ARI scores noted. These were found to be statistically significantly different (Table 3) with more adhesive remaining on the enamel surface following the use of conventional etching and a diacrylate adhesive, than following the use of poly(acrylic acid) conditioning and a resin-modified glass polyalkenoate cement. This contrasts with the results of another study that found that less adhesive remained on the enamel surface following the use of a filled diacrylate and acid etching than with a resin-modified glass polyalkenoate cement and a poly(acrylic acid) conditioned surface (David *et al.*, 2002).

Finally, enamel loss following one of four methods of enamel clean-up was investigated. In both the Transbond XT and Fuji Ortho LC groups there were statistically significant differences between the four methods of enamel clean-up (Figure 5). With Transbond XT, the enamel loss was greatest with the ultrasonic scaler (–1.27 to –31.41 μm) and with the high-speed tungsten carbide bur (2.12 to –28.74 μm). Similarly, with Fuji Ortho LC, enamel loss was also greatest using the ultrasonic scaler (5.19 to –16.94 μm) and the tungsten carbide bur in a high-speed handpiece (0.83 to –15.15 μm). When each method of enamel clean-up was considered in turn, there was a statistically significant difference in enamel loss between the Transbond XT and Fuji Ortho LC groups. More enamel was lost in the Transbond XT group with each method of clean-up. Although the precise reason for the differences between the materials is unknown, it is possible that this may be related to the amount of residual adhesive requiring removal following debonding, which was greater in the case of Transbond XT. In both the main treatment groups, the least amount of enamel loss was observed following the use of the tungsten carbide bur in the slow-speed handpiece. This loss ranged from only –0.05 to –4.43 μm with Transbond XT (Figure 5a) and from 0.75 to –0.42 μm with Fuji Ortho LC (Figure 5b).

The positive values for enamel loss seen following enamel clean-up with the debanding pliers, the ultrasonic scaler and Fuji Ortho LC, and to a lesser extent the tungsten carbide bur in a high-speed handpiece with Transbond XT (Table 2), indicate that residual adhesive was probably still present following clean-up, even though the enamel appeared macroscopically clean.

The total enamel loss in all cases, along with residual adhesive remaining on the enamel surface after clean-up, was much less than has previously been observed. Krell *et al.* (1993) reported a mean loss of enamel of 149.87 μm (standard deviation 202.18) following the use of a high-speed tungsten carbide bur, and a mean loss of 0.47 μm (standard deviation 38.48) following clean-up with an ultrasonic scaler. It is possible that enamel loss in the clinical

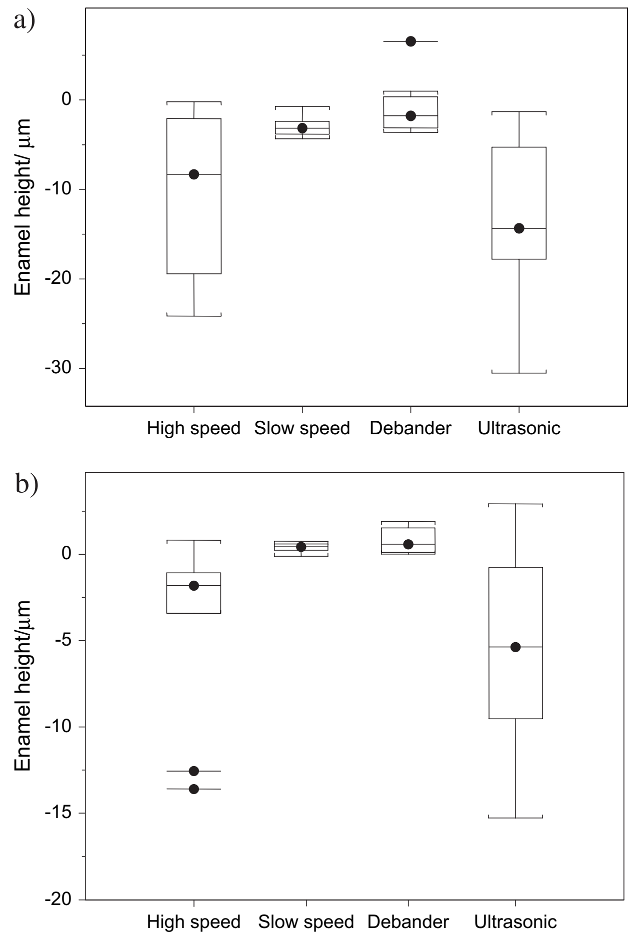

Figure 5 Box and whisker plots showing median enamel surface height, interquartile range, and maximum and minimum with outliers (μm) for (a) the Transbond with conventional etch group after clean-up and (b) the Fuji Ortho LC group after clean-up.

situation, certainly at the acid etching/conditioning stage, may be even less, as in the present experiment specimen preparation involved grinding the tooth flat. This will have inevitably led to the removal of some of the fluoride-rich surface layer of the enamel.

It would therefore seem that in order to minimize enamel loss, orthodontic brackets should be bonded using a resin-modified glass polyalkenoate cement. Following debonding, the enamel should be cleaned using a spiral fluted tungsten carbide bur in a slow-speed handpiece.

Conclusions

1. Significantly more enamel was lost following acid etching with 37 per cent *o*-phosphoric acid than with acid conditioning using 10 per cent poly(acrylic acid).
2. Following bracket debonding, significantly more residual adhesive remained on the enamel surface in the case of the 37 per cent *o*-phosphoric acid with Transbond

XT group, than in the poly(acrylic acid) conditioner with Fuji Ortho LC group.
3. At enamel clean-up, the greatest enamel loss was seen following the use of the ultrasonic scaler or high-speed tungsten carbide bur and the least with the slow-speed tungsten carbide bur.
4. Overall, significantly less enamel was lost following the use of the poly(acrylic acid) conditioner with Fuji Ortho LC group than following conventional etching and Transbond XT with all four enamel clean-up methods.
5. The least enamel loss was observed with the use of poly(acrylic acid) conditioner in the Fuji Ortho LC group following enamel clean-up using the slow-speed tungsten carbide bur.

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