The effect of carbamide peroxide bleach on the tensile bond strength of ceramic brackets: An in vitro study

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Recent advances in cosmetic dentistry have led to the development of a variety of new products and techniques including vital bleaching and ceramic brackets. Therefore this study was conducted to see whether the use of an at-home carbamide peroxide bleaching agent before bonding affected the tensile bond strength of a precoated ceramic orthodontic bracket. Sixty extracted human premolar teeth were randomly separated into three groups of 20. Group 1 was a control group that was etched and bonded in the usual manner. Group 2 was immersed in a carbamide peroxide home bleaching agent for 72 hours before pumicing and bonding. Group 3 was also bleached for 72 hours but was immersed in distilled water for 1 week before bonding. The results indicated that recently bleached teeth have significantly reduced bond strength values when compared with both groups 1 and 3. We suggest that if a patient is using a tooth whitening product, that they discontinue its use at least 1 week before the bonding of orthodontic attachments. (Am J Orthod Dentofac Orthop 1994;106:371-5.)

Since the introduction of acid etching by Buonocore in 1955,[1] bonding techniques have advanced rapidly affecting many aspects of dentistry including orthodontics. Newman[2] first applied these techniques to direct bonding of orthodontic attachments to the tooth surface. Modern bonding techniques along with the advent of the ceramic bracket have offered cosmetic options to patients not previously available. With the increased awareness of cosmetic dentistry within the community, the advent of vital bleaching has also captured the imaginations of the public and the dental profession by offering the option of a whiter, more attractive smile. The more recent innovation of at home vital bleaching has fueled this rapid growth in the marketplace despite limited research about any systemic or local effects.

Previous studies have shown a change in enamel structure, composition, and bond strength when exposed to 35% hydrogen peroxide (HP) as used for in office vital bleaching procedures.[3,4] Ruse and coworkers[3] noted an increase in nitrogen concentration when bovine enamel was immersed in HP for 60 minutes. However, they concluded that the marked reduction in bond strength caused by bleaching was not related to a peroxide-induced change in the elemental composition of the surface enamel. The possibility of other chemical alterations could not be ruled out by this finding.

Titley et al.[4] reported that after 60 minutes of HP immersion, a white precipitate could be discerned in association with the enamel surface. This scanning electron microscopic (SEM) study also showed that acid etching of the enamel before HP exposure led to a white precipitate forming after only 20 minutes. After 60 minutes immersion the precipitate was so dense that the surface structure of the enamel was obscured. Other studies by the same authors have shown that HP treatment of bovine enamel decreased bond strength.[5-8] They surmised that this may be due to the presence of residual HP on the enamel.[5] The authors therefore conducted a further study where, after bleaching, the bovine enamel was immersed in double-distilled water at 37° C for 7 days before bonding.[9] This yielded a significantly higher bond strength for the HP-treated specimens as compared with the control specimens. None of these studies, however, pumiced the specimens before bonding as would be done clinically. Pumicing, by its cleaning and abrasive action, may have been sufficient to remove any surface contaminants affecting bond strength.

The previously mentioned bleaching studies also used bovine enamel. Although it is generally accepted that the mechanism of etching and bond-

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ing is essentially the same as human enamel, the effects of bleaching has not been investigated.[10] Little evidence exists at present as to any effects of the more accessible at-home carbamide (urea) peroxide products on human enamel and whether this would be of any consequence in orthodontic bonding. The present study was therefore conducted to investigate the effect of a 10% carbamide peroxide bleaching agent on the tensile bond strength of precoated ceramic orthodontic brackets bonded to human premolar teeth.

MATERIALS AND METHODS

Sixty extracted premolars (first and second, upper and lower) were collected and randomly divided into 3 groups of 20 teeth each and were stored in 0.9% sodium chloride. The criteria for tooth selection dictated grossly perfect buccal enamel, no cracks or caries present and no pretreatment with chemical agents such as alcohol, formalin, hydrogen peroxide or any other form of bleaching agent. A commercially available 10% carbamide (urea) peroxide gel (Rembrandt Lighten, Denmat Products, Santa Maria, Calif.) was used as the bleaching agent. The recently released Transcend precoated polycrystalline ceramic brackets (Transcend II, Unitek Corp., Monrovia, Calif.) donated by 3M/Unitek were used in this study. These brackets are supplied with a prescribed amount of bonding agent already applied to the bracket base. The manufacturers specifications for these brackets indicate they have a base surface area of 0.018 inch^2 (11.4 mm^2). We confirmed this with a vernier caliper. All teeth were bonded by one operator, and all materials were handled as per the manufacturer's instructions.

Group 1 (control): The teeth were rinsed with tap water by using an air/water syringe for 20 seconds, cleaned with a prophylaxis cup in a slow speed handpiece with a slurry of nonfluoridated pumice for 30 seconds, rinsed for an additional 20 seconds, and dried with oil-free compressed air for 20 seconds. A 37% phosphoric acid liquid etchant was applied to the buccal surfaces for a period of 20 seconds. The teeth were then rinsed for 20 seconds and warm air dried for 20 seconds. A layer of the bonding agent was applied to the etched surface before bonding. The brackets were placed on the midbuccal surface of the crown and firm seating pressure was applied until bracket to tooth contact was achieved. Any excess material was removed from around the bracket base. The specimens were then light cured (Ortholux, Unitek Corp., Monrovia, Calif.) for a period of 20 seconds. After 10 minutes, the teeth were stored in distilled water at room temperature for 1 week before debonding.

Group 2 (bleach only): The buccal surfaces of the crowns were rinsed with an air/water syringe for 20 seconds, cleaned with a prophylaxis cup in a slow speed handpiece with a slurry of nonfluoridated pumice for 30 seconds, rinsed for a further 20 seconds, and then air dried for 20 seconds. After drying, the teeth were immersed in the bleaching agent for a period of 72 hours at room temperature with the bleaching gel being changed every 8 hours. The teeth were removed from the gel, washed, pumiced, bonded, and stored using the same regimen as the control group.

Group 3 (bleach and water): This group was treated the same as group 2 except that after bleaching and before bonding, the teeth were stored in distilled water for 1 week at room temperature.

Tensile tests

To test the tensile strength, a modified Transcend series 2000 debonding instrument (Unitek Corp., Monrovia, Calif.) was attached to the bracket as recommended by the manufacturer (Fig. 1). The other end of this instrument was attached to an Instron Universal testing machine (Instron Corporation, Canton, Mass.) that was set with a crosshead speed of 1 inch/minute (2.54 cm/min) and the specimens stressed to failure. The debonding tool has a mode of action that stabilizes the tooth while applying a tensile force to the bracket. This technique has been used previously in this laboratory and has been found to be highly reliable and efficacious. The debonding instrument was examined after every test to ensure that the metal jaws were not distorted. The tensile bond strength was recorded to the nearest 0.5 pounds (0.19 MPa) for each specimen. One bracket in group 3 fractured at 21.5 pounds (8.23 MPa) without debonding, and the group mean was substituted for the missing value. The brackets were then examined with a stereomicroscope to examine the site of bond failure. This examiner was blind to the test groups of the brackets. When examining the bracket base, the surface was divided into nine equal segments. This method was used to quantitatively distinguish between bracket to resin failure and cohesive failure within the resin. On each bracket, the number of segments with resin still attached was recorded.

RESULTS

Fig. 2 illustrates the tensile bond strengths of the three groups. Bond strength mean differences among the three groups were tested for statistical significance with an analysis of variance (ANOVA) for fixed effect ($p < 0.0001$). Post hoc pairwise mean comparisons were performed with Tukey's HSD procedure. This analysis resulted in group 2 (bleached) having a significantly lower mean strength than either group 1 (control) or group 3 (bleached followed by water immersion) ($p < 0.05$). The control group and group 3 were not significantly different at the 0.05 level. A Kruskal-Wallis (K-W) nonparametric test ($p < 0.0001$) followed by post hoc Bonferroni adjusted Mann-Whitney U test corroborated the ANOVA results.

Because of the extreme skewness of the group

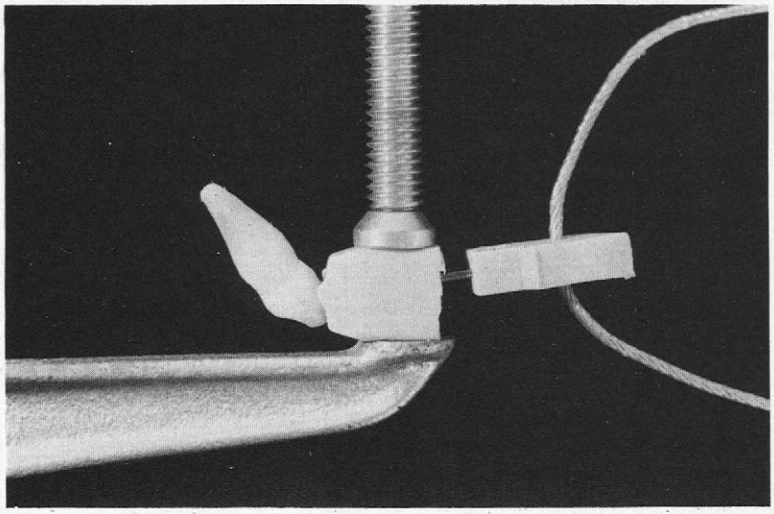

Fig. 1. Modified Transcend series 2000 debonding instrument attached to bracket.

Table I. Resin remaining on the bracket base

Number of segments	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*Failed*
Bleach	14	0	3	1	0	0	2	0	0	0	0
Control	17	2	0	1	0	0	0	0	0	0	0
Bleach with water	19	0	0	0	0	0	0	0	0	0	1

distributions on the attached resin variable (Table I), only the nonparametric tests of significance were applied to this data. The K-W test for differences in attached resin among the three groups was significant at $p = 0.0256$. The Mann-Whitney U pairwise comparison indicated significantly greater amounts of attached resin on the brackets of group 2 versus group 3 ($p = 0.0091$). Group 2 versus control ($p = 0.1888$) and control versus group 3 ($p = 0.0756$) were not significantly different on attached resin at the 0.05 level. In group 3, none of the brackets had any resin remaining on the base after debonding.

Five brackets fractured during the study, one of these did not debond from the tooth. Three of these brackets were from group 2 and two were from group 3. Four of these brackets had both gingival wings fracture. All these brackets fractured at the level of the slot. A fifth bracket failed at the level of the tie wings with one occlusal wing fracturing.

DISCUSSION

This study was designed to follow bonding procedures as may normally be applied in the clinical situation. The use of the precoated Transcend 2000 ceramic brackets over other ceramic or metal brackets in this study was for two reasons: First, to reduce the number of variables in the bonding procedure by using a precoated bracket. Second, if a patient is esthetically concerned enough to have tried a bleaching procedure, then they may also be more likely to demand ceramic brackets if undergoing orthodontic treatment.

The effects of carbamide peroxide bleaching agents have received little scrutiny to date, probably because of their recent explosion onto the market. Carbamide peroxide gels provide 25% to 35% hydrogen peroxide equivalent, and its effect on human enamel composition and topography has been studied by Covington et al.[11] Their results suggested a controlled oxidation process in which the organic phase of the enamel is mobilized without producing grossly unacceptable enamel surface topography. Allison et al.[12] showed an alteration in the topography of acid etched enamel of carbamide peroxide bleached teeth with the loss of the regular prism boundaries when compared with a control. Scherer et al.[13] demonstrated that the use of a brush-on carbamide peroxide gel system for up to 30 days was found to have no effect on surface structure under SEM examination.

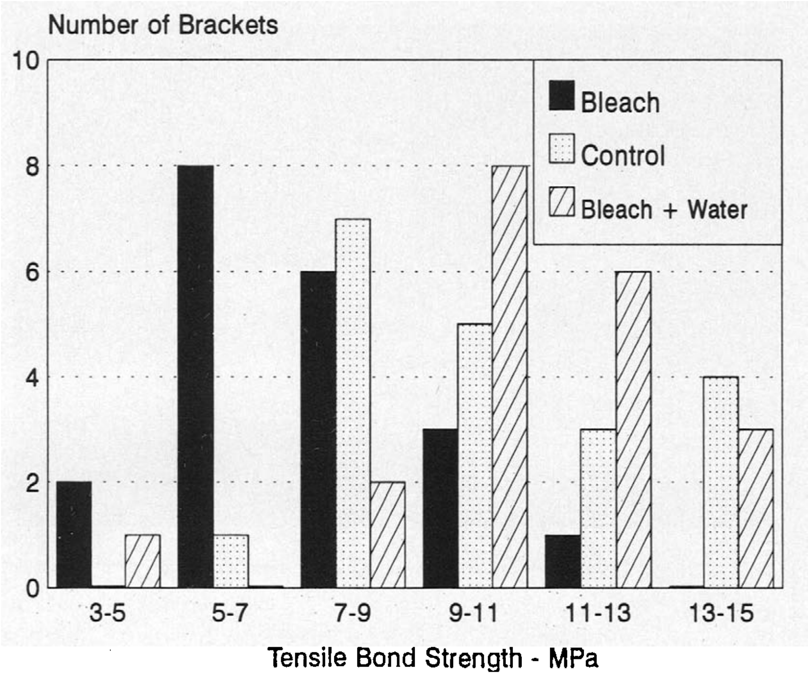

Fig. 2. Tensile bond strengths in MPa.

Standard clinical technique involves the use of a slurry of pumice with a prophylaxis cup or bristle brush before bonding. The use of a rubber cup or bristle brush has been shown to mechanically abrade the enamel surface to average depths of 5.0 μm and 10.7 μm, respectively.[14] This abrasive action along with the cleansing action of prophylaxis may be enough to reduce any HP or other contamination on the enamel surface to a level that does not significantly affect bond strength. Cvitko et al.[15] recently reported a significant reduction in shear bond strength to the preflattened enamel surface of carbamide peroxide bleached teeth that were pumiced before etching and bonding. This study supports this finding. The significant decrease in bond strength and increased amounts of resin remaining on the brackets in the bleaching only group support the hypothesis that residual bleaching agent has unduly affected the bonding process. This affect is negated if the specimens are immersed in water for 1 week before bonding. This may be due to any residual material affecting bonding being removed by the immersion process. In vivo, saliva may have a similar action after clinical bleaching. This would suggest that bleaching should be ceased 1 week before orthodontic bonding to ensure adequate bond strengths.

Previous studies measuring both tensile and shear bond strengths of composite resin to bleached enamel have found equally significant reductions.[5,6,9] For this reason, it was believed that it was not necessary to measure both parameters. The tensile bond strength was used due to the ease and practicality of the previously described debonding technique. Although many previous studies compare their results with the tensile bond strengths suggested by Reynolds in 1975,[16] we did not consider this appropriate. Reynolds stated that a maximum value of 60 to 80 kg/cm^2 would appear reasonable for successful bonding but had no data nor quoted references to support this opinion. Despite it being referred to as an accepted standard in the literature, we did not consider it sufficiently sound for comparison.

When examining the fractured brackets, four were seen to fail at the level of the wire slot. It was particularly evident that the weakness in the bracket at debonding is the gingival tie wings as these failed specimens were seen to fracture at this location. This may be due to the slot being closer to the gingival tie wings. The bracket is therefore thinner in this location. The fifth failed bracket fractured above the slot, in the occlusal tie wing that may have been due to damage or a flaw in this portion of the bracket resulting in a different pattern of breakage. Although the fit of the debonding tool on the bracket was checked carefully before debonding, the possibility also exists that the jaws of the tool were not properly seated.

Other patient-applied bleaching products are currently available that contain hydrogen peroxide and calcium peroxide.[17] As their actions as oxidizing and proteolytic compounds are similar to carbamide peroxide, we would expect their effects on bond strength to be similar until shown otherwise.

CONCLUSIONS

1. The use of a carbamide peroxide bleaching agent immediately before bonding significantly reduces bond strength.
2. Immersion of bleached teeth in water for 1 week before bonding results in a return to control bond strength.
3. The debonding occurs in the majority of cases, at the bracket/resin interface.
4. The Transcend debonding tool was able to safely debond the brackets with only 1 of 60 brackets fracturing without debonding.

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