Effect on Enamel Microhardness of Two Consumer-Available Bleaching Solutions When Compared with a Dentist-Prescribed, Home-Applied Bleaching Solution and a Control

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ABSTRACT

Background: There exists limited data in the literature regarding the efficacy and safety of consumer-available, paint-on bleaching solutions.

Purpose: The purpose of this in vitro study was to evaluate the effect of two consumer-available, paint-on bleaching products on enamel microhardness against a control and a dentist-prescribed, home-applied (DPHA) bleaching product.

Materials and Methods: Eighty enamel slabs were obtained from extracted human teeth and randomly divided into four treatment groups: (1) control; (2) Opalescence (Ultradent Products, Inc., South Jordan, UT, USA); (3) Crest Night Effects (Procter & Gamble, Cincinnati, OH, USA); and (4) Colgate Simply White Night (Colgate-Palmolive Co., Piscataway, NJ, USA). Opalescence is a carbamide peroxide DPHA product, whereas Crest Night Effects and Colgate Simply White Night are consumer-available products. The specimens in groups 2 to 4 underwent 2 weeks of treatment for 8 h/d. Specimens were maintained in artificial saliva at 37°C between treatments. Subsequently, one-half of the specimens in groups 2 to 4 (n = 10) underwent an additional seven treatments for 8 h/d, while the other half were stored in artificial saliva, receiving no further treatment. Microhardness was measured as Knoop hardness numbers (KHNs) at baseline and after 1, 7, 14, and 21 treatment days. The results were analyzed for statistical significance both intra- and intergroups using analysis of variance (p = .05).

Results: A statistically significant reduction in mean KHN was observed compared with baseline at 1, 7, 14, and 21 treatment days for group 4 and at 7 treatment days for group 3. When compared with the control or DPHA product, group 4 was the only treatment that resulted in significantly lower mean KHNs at 7, 14, and 21 treatment days.

Conclusion: When evaluating enamel microhardness, consumer available, paint-on bleaching solutions may adversely affect enamel microhardness compared to a control and 10% carbamide peroxide DPHA bleaching solution.

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CLINICAL SIGNIFICANCE

With numerous consumer-available bleaching products on the market, it is crucial to be judicious in their selection and use. The results of this in vitro study showed that the consumer-available, paint-on bleaching solutions adversely affected enamel microhardness at some time during the study. Consumers should be made aware of this effect on enamel.

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Dentist-prescribed, home-applied (DPHA) bleaching has been widely accepted by patients and dentists as a simple and safe way to lighten discolored teeth. The dental literature contains numerous articles describing the efficacy of this procedure.[1–12] With respect to safety, 10% carbamide peroxide (CP) and low-concentration hydrogen peroxide (HP) solutions have been shown to be safe bleaching agents with minimal alterations to the enamel surface.[2,4,12–22]

Following on the heels of the success of DPHA bleaching, when using either CP or HP in a custom-fabricated tray, manufacturers have developed new tooth-whitening modalities, including innovative delivery systems. It was hoped that these new modalities would be just as effective as the tray system but with fewer side effects and shorter treatment times, which would lead to better patient compliance.

Recently introduced into the marketplace are paint-on bleaching solutions. These barrier-free solutions are available directly to the consumer and are easy to use. Unlike DPHA bleaching, in which the dentist dispenses the bleaching solution and supervises the procedure, patients have unlimited access to consumer-available bleaching products without any professional supervision. Consumer-available bleaching products contain various bleaching ingredients of different concentrations and pH levels, and various chemicals to extend shelf life and increase their effectiveness. In addition, some contain phosphoric, etidronic, or citric acid to condition the tooth for bleaching (Plus+White 5 Minute Whitening System, Plus+White, East Rutherford, NJ, USA; Rembrandt Dazzling White, Rembrandt, Santa Maria, CA, USA; Natural White Pro, Natural White, Tonawanda, NY, USA). The effect of these chemicals on enamel and dentin has not been thoroughly investigated. As the popularity and number of consumer-available bleaching products increase, the risk for consumer misuse, as well as abuse, also increases. This would be damaging not only to the patient but to dentistry as well.

Two popular consumer-available, paint-on bleaching products on the market today are Crest Night Effects (Procter & Gamble, Cincinnati, OH, USA) and Colgate Simply White Night (Colgate-Palmolive Co., Piscataway, NJ, USA). Crest Night Effects is an anhydrous system that contains percarbonate gel in a silicone polymer suspension that dries to form an adherent film on the tooth; this film hydrates in vivo to slowly release peroxide (5.3% HP) into the tooth. Colgate Simply White Night is a liquid gel containing 8.75% HP. Currently there exists limited and equivocal data in the peer-reviewed literature as well as in non–peer-reviewed supplements and special issues regarding efficacy and safety of consumer-available bleaching solutions, especially when pertaining to paint-on solutions.[23–32] Therefore, the objective of this in vitro study was to evaluate the effects of Crest Night Effects and Colgate Simply White Night during a 3-week treatment period on enamel microhardness when compared with a control and a 10% CP DPHA tray-delivered bleaching solution (Opalescence, Ultradent Products, Inc., South Jordan, UT, USA). It is hypothesized that consumer-available, paint-on bleaching solutions will not affect the enamel surface microhardness.

MATERIALS AND METHODS

Freshly extracted human third molars, approximately 1 month old, that had been stored in chloramine-T, were cleaned and disinfected. Specimen preparation and test design is illustrated in Figure 1. All roots were removed and 80 enamel slabs measuring 3 × 3 × 2 mm were obtained from the crowns using a double-sided diamond disk (Brasseler USA, Savannah, GA, USA). Specimens were embedded individually in phenolic rings (Buehler Ltd., Lake Bluff, IL, USA) with polyester resin (Castoglass Resin, Buehler Ltd.) and were wet polished through 1,200-grit SiC abrasives (Buehler-Met II, Buehler Ltd.). Baseline surface microhardness data were collected from all specimens to determine whether block randomization was required to avoid bias owing to an unintended pooling of specimens with extreme values. Using a hardness testing machine (Micromet 2100, Buehler Ltd.), three indentations were made in each specimen with a 50 g load applied for 15 seconds to the enamel surface. No block randomization was necessary.

The specimens were randomly divided into four treatment groups (n = 20): (1) control (no treatment, stored in artificial saliva[33]); (2) Opalescence (10% CP, equivalent to 3.3% HP); (3) Crest Night Effects (19% sodium percarbonate, equivalent to 5.3% HP); and (4) Colgate Simply White Night (8.75% HP). The specimens in groups 2 to 4 underwent 14 treatment applications, which is the number of

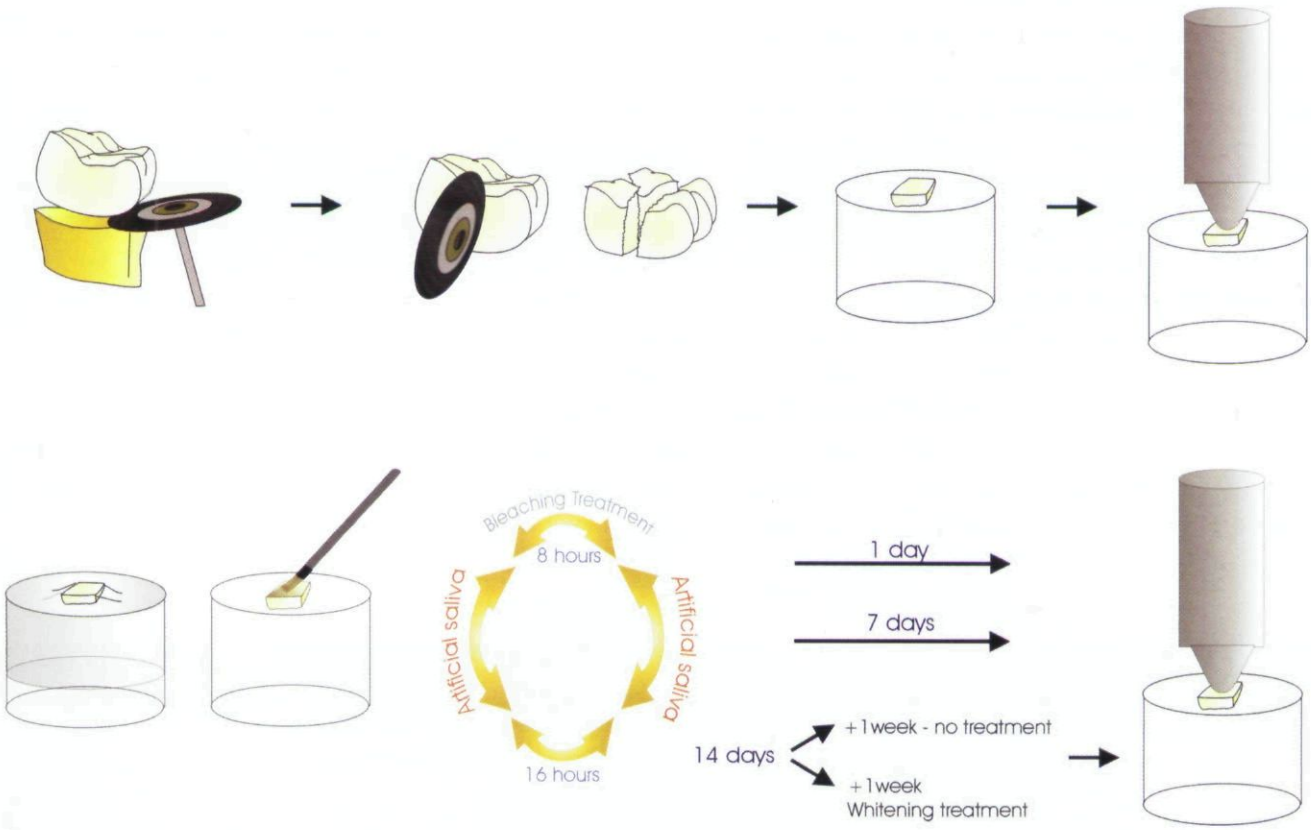

Figure 1. Specimen preparation and test design. Roots were removed from crowns, and enamel slabs were obtained and embedded in polyester resin. Surface microhardness was measured at baseline and 1, 7, and 14 days of treatment. Half of the specimens received 7 more days of treatment while the others were stored in artificial saliva. All were then retested for microhardness. Specimens were treated according to experimental groups (see Materials and Methods).

applications prescribed by the manufacturers. Each specimen was treated for 8 h/d, which is the equivalent of overnight use. After the standard treatment, specimens from each group were divided into two equal subgroups (n = 10). Ten specimens from groups 2 to 4 underwent an additional 7 treatments, which would represent a potential overuse of treatment for groups 3 and 4. The nontreated half (n = 10) of the specimens from groups 2 to 4 were stored in artificial saliva during this time and received no further treatment. For groups 3 and 4, the bleaching solutions were applied directly to the specimens, forming a uniform thin layer over the entire enamel surface. For group 2, an individual tray without a reservoir was fabricated for each specimen using a 0.35 mm thick ethyl vinyl acetate polymer tray material in a vacuum-forming machine (Sta-Vac, Buffalo Dental Mfg. Co. Inc., Syosset, NY, USA).[33] Following each treatment session, specimens were rinsed with distilled deionized water, immersed in individual containers with artificial saliva, and stored at 37°C (± 1°C). The formulation for the artificial saliva used contained calcium and phosphate.[33]

Throughout the study, microhardness testing was done as described for baseline surface microhardness at 1, 7, 14, and 21 days. Repeated-measures analysis of variance was performed for the mean Knoop hardness number (KHN) values at a p value of .05 (SPSS 9.0, Chicago, IL, USA). Paired t-tests were used to analyze the difference of microhardness mean values between baseline and 1, 7, 14, and 21 days within each experimental group when the analysis of variance was significant. Tukey's multiple comparisons test was used to check significant differences in means among groups within each time interval.

RESULTS

Mean KHN values (± SD) for enamel surface microhardness at each time interval are reported in Tables 1 and 2. There were no statistically significant differences between mean KHNs for specimens in treatment groups and those in the control group (group 1) at 1 day of treatment. At 7 treatment days, Tukey's test revealed that group 4 had statistically lower mean KHN values than did groups 1 and 2. No significant difference was observed between group 3 and the other groups. At 14 treatment days, the only group that exhibited statistically lower mean KHN values than the control group was group 4.

Paired t-test analysis between baseline and 1, 7, 14, and 21 days was also carried out to evaluate the behavior of the treated groups throughout the time intervals. A significant reduction in the mean KHN values was observed from baseline to all other time intervals for group 4. A statistically significant difference was measured at 7 treatment days for group 3 but not at 14 treatment days. No statistically significant differences were noted between the two overuse subgroups (3 and 4) that did not already exist after 14 treatment days.

DISCUSSION

The null hypothesis for our in vitro study was that paint-on bleaching products would not be detrimental to the enamel surface and would

TABLE 1. MEANS OF ENAMEL SURFACE MICROHARDNESS VALUES (KHN ± SD) AT DIFFERENT TIME INTERVALS FOR 2-WEEK STANDARD TREATMENT.

Group	n	Baseline	1 Day	7 Days	14 Days
1. Control: artificial saliva	20	356.5 ± 27.9[a]	335.9 ± 26.7[a]	330.6 ± 49.0[a]	343.1 ± 44.1[a]
2. Opalescence 10%	20	356.3 ± 28.5[a]	351 ± 28.8[a]	332.6 ± 54.3[a]	327.5 ± 59.6[a]
3. Crest Night Effects	20	358.2 ± 28.8[a]	352.7 ± 31.8[a]	315.8 ± 35.1[ab]*	335.3 ± 44.9[a]
4. Colgate Simply White Night	20	373.5 ± 34.0[a]	331.5 ± 32.2[a]*	274.9 ± 61.1[b]*	210.9 ± 50.1[b]*

*Represents significant differences between baseline and 1, 7, and 14 days in rows ($p < .05$). Means with the same superscript letter in columns are not significantly different ($p \geq .05$).

TABLE 2. MEANS OF ENAMEL SURFACE MICROHARDNESS VALUES (KHN ± SD) AT 21 DAYS AFTER DIFFERENT PROCEDURES.

Group	1 Week in Saliva after Standard Treatment ($n = 10$)	1 Week of Overuse after Standard Treatment ($n = 10$)
1. Control: artificial saliva	333.3 ± 59.6	342.0 ± 48.8
2. Opalescence 10%	324.5 ± 45.2	324.2 ± 50.2
3. Crest Night Effects	336.4 ± 38.1	334.6 ± 46.6
4. Colgate Simply White Night	216.9 ± 53.9*	212.6 ± 72.7*

KHN = Knoop hardness number.
*Represents significant differences between groups in columns ($p < .05$).

therefore not affect enamel surface microhardness. With respect to the two consumer-available paint-on solutions evaluated, our results showed that at some point during treatment, enamel microhardness was adversely affected. However, the only product that significantly affected enamel microhardness, either after completion of treatment when used according to the manufacturer's instructions (14 treatments) or after an additional 7 treatments (representing consumer overuse), was Colgate Simply White Night.

Microhardness measurements are used as a parameter to measure changes that can be related to either loss or gain in mineral content of enamel. This approach has been used many times to evaluate the effect of bleaching products on tooth structure and restorative materials.[34–36]

Our 14-day results for the Crest Night Effects group agree with the results reported by White and colleagues.[32] In their study it was also observed that a 19% percarbonate whitening film had no statistically significant effect on enamel or on root dentin microhardness.

Although in vitro studies have been established to evaluate properties and the effects of new materials on tooth structure, it would be difficult to extrapolate the results, with a high degree of certainty, to clinical situations. For this study, artificial saliva with calcium and phosphate was used, which would be present for remineralization intraorally, to simulate physiologic conditions.

We found that a DPHA 10% CP bleaching solution did not have a significant effect on enamel microhardness values when treated for up to 3 weeks. These results are in agreement with other published studies.[17,36,37] With respect to potential damage to enamel if the consumer overuses the bleaching solutions for 7 additional treatments, our study did not find any significant difference that did not already exist after 2 weeks of treatment.

With respect to the paint-on bleaching solutions, our in vitro study may represent the worse-case scenario for evaluating the effect of the bleaching solutions used. The solutions were applied directly to the dried tooth and stayed on the tooth for the entire treatment period. Clinically, the user of these materials may not be able to dry the teeth as well as we did in the laboratory. Additionally, absent in the laboratory would be the effect of the tongue, lips, and cheek to mechanically remove the bleaching material from the teeth as well as the dilution factor of saliva. All these factors would play a major role in how effective the product was in bleaching teeth.

A possible explanation for the change in enamel microhardness of the groups studied, especially Colgate Simply White Night, could be the HP concentration of the different solutions. As shown in Table 3, Colgate Simply White Night has the highest concentration of HP of all solutions used, about 1.5 times that of Crest Night Effects and 2.5 times that of Opalescence. Since the dilution of saliva and the mechanical action of the tongue, lips, and cheeks were not factors in this study, it seems reasonable that the higher HP solution would have the greatest effect on the enamel. Additionally, Colgate Simply White Night has a direct release of HP, whereas Crest Night Effects and Opalescence provide an indirect release of HP through their main

TABLE 3. SOLUTIONS USED IN STUDY AND HYDROGEN PEROXIDE CONCENTRATIONS OR EQUIVALENTS.

Groups	Active Ingredient	% Hydrogen Peroxide or Equivalent
1. Control	None	0.0
2. Opalescence	10% carbamide peroxide	3.3
3. Crest Night Effects	19% sodium percarbonate	5.3
4. Colgate Simply White Night	8.75% hydrogen peroxide	8.75

components, sodium percarbonate and CP, respectively. It has been shown that bleaching with 3% HP can cause a detrimental effect on the tooth structure.[37] However, 10% CP, which corresponds to 3.3% HP, has been shown to have no adverse effect on enamel microhardness or surface morphology.[37,38] Therefore, the release form (direct or indirect) and/or chemical reactions with tooth structure could also be reasons for the results observed. When applied to a clinical situation, the statistical difference we saw in vitro may not occur.

Another factor could be the effect of phosphoric acid, which is contained in Colgate Simply White Night but not in Crest Night Effects. The majority of the over-the-counter products vary in their chemical composition and makeup. The influence of the various components such as carbopol, glycerin, different acids as well as different pH levels between these solutions is still unknown. The effect of these components on tooth structure should be evaluated. Further studies using different experimental methods should be performed to obtain more answers about the broad range of consumer-available tooth-bleaching products that are on the market today.

CONCLUSIONS

From this study it can be concluded that consumer-available bleaching products may adversely affect enamel microhardness depending upon the product chosen. A significant decrease in the KHN was observed, which could harm the tooth enamel surface. With numerous over-the-counter bleaching products available on the market, the consumer should be cautioned of the possible effects that these products might have on enamel.

DISCLOSURE

The authors do not have any financial interest in the companies whose materials are discussed in this article.

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