Effects of a 10% Carbamide Peroxide Bleaching Agent on Roughness and Microhardness of Packable Composite Resins

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ABSTRACT

Purpose: Bleaching agents containing 10% carbamide peroxide may be applied to the surface of preexisting packable resin-based composite restorations. The aim of this in vitro study was to evaluate the effect of a 10% carbamide peroxide bleaching agent (Review, SS White, Rio de Janeiro, Brazil) on surface roughness and microhardness of three packable resin-based composites (Fill Magic condensable, Vigodent, Rio de Janeiro, Brazil; Alert, Jeneric Pentron, Wallingford, CT, USA; Definite, Degussa, Hanau, Germany).

Materials and Methods: For the control (no bleaching) and experimental (bleaching treatment) groups, 12 specimens of each material were prepared in cylindrical acrylic molds. The experimental specimens were exposed to the bleaching agent for 6 hours a day for 3 weeks. During the remaining time (18 h), they were stored in artificial saliva. The control specimens remained immersed in artificial saliva throughout the experiment. Surface roughness and microhardness measurements were performed on the top surface of each specimen.

Results: Analysis of variance and the Tukey test showed no significant differences in roughness among the packable composites evaluated ($p = .18$), but those submitted to the treatment with a 10% carbamide peroxide bleaching agent displayed significantly higher mean surface roughness than did the corresponding control group for each material. For the microhardness tests, there were significant differences among materials ($p < .0001$). Alert showed the highest microhardness values followed by Definite and Fill Magic condensable.

Conclusions: Ten percent carbamide peroxide bleaching agents may change the surface roughness of packable composites, but they do not alter their microhardness.

CLINICAL SIGNIFICANCE

Under the conditions of this study, a 3-week bleaching regimen with 10% carbamide peroxide agents affected the roughness of packable composites. Nevertheless, the surface microhardness was not affected, although there were differences among the materials evaluated inherent to their composition.

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Home-use bleaching treatments have become a popular way to enhance esthetics,[1] owing to their efficiency and simplicity.[2] Although different carbamide peroxide concentrations (10–35%) have been introduced to the market, 10% carbamide peroxide is the most widely used bleaching agent for supervised at-home bleaching procedures with American Dental Association (ADA) approval.[3] It is an unstable solution that breaks down into 7% urea and 3% hydrogen peroxide. The latter is considered the active agent of the bleaching reaction that permeates through the structure of enamel and dentin and provides the lightening of stains by an oxidation process.[2] However, because of the lower concentration of hydrogen peroxide released, more time is required to achieve similar results to those achieved with in-office techniques that use 30 to 35% hydrogen peroxide.[2]

Some of the effects of 10% carbamide peroxide bleaching materials on enamel and dentin surface have been evaluated. Changes in microhardness,[4–10] micromorphology,[10–19] and superficial roughness have been observed,[16] although saliva and fluorides seem to maintain or recover the alterations in mineral and organic content.[20] The main reasons for the surface changes in tooth structure seem to be related to the pH of the bleaching agents, exposure time, carbamide peroxide concentration, and components of the bleaching products.[13,15,16,19,21]

Bleaching agents containing 10% carbamide peroxide may be applied to the surface of preexisting restorations. The use of these solutions on restorative materials—especially composite resins—seems to result in different effects on surface hardness and roughness, depending on the composition of the material, bleaching agent, and regimen treatment employed.[22–26] When applied on amalgam, carbamide peroxide bleaching gels have been shown to produce mercury release and consequently bring about problems with toxicity.[27–29]

An alternative to the use of amalgam in posterior teeth has appeared with the introduction of packable resin-based composites for posterior restorations.[30,31] They are claimed to be an encouraging material to replace amalgam owing to resulting modifications found in the filler particles, low polymerization shrinkage, and improved physical and mechanical properties.[30,32,33] However, the effects of a 10% carbamide peroxide bleaching agent on surface roughness and microhardness of condensable composite resins still remain unknown. This study evaluated the effects of a 10% carbamide peroxide bleaching agent on the surface roughness and microhardness of three different condensable composite resins.

MATERIALS AND METHODS

Experiment Design

The materials studied were condensable composite resins (Fill Magic condensable, Alert, Definite) and a 10% carbamide peroxide bleaching agent (Review), used for superficial treatment. All the materials used are described in Table 1. Twenty-four specimens of each composite were randomly distributed into the control ($n = 12$, no treatment) and experimental ($n = 12$, 10% carbamide peroxide bleaching agent treatment) groups. Roughness and microhardness responses were evaluated by quantitative methods. Three sequential superficial roughness measurements and five microhardness indentations were taken on the surface of each specimen. The statistical analysis (analysis of variance [ANOVA] and the Tukey test) employed the average of these replicates for roughness and microhardness.

Specimen Preparation

Seventy-two specimens were prepared in cylindrical acrylic molds with internal dimensions of 2.0 mm in height and 4.0 mm in diameter. For the control and experimental groups, 24 specimens of each material were produced. The materials were prepared according to the manufacturers' instructions. The condensable composite resins were dispensed from the syringe without any manipulation and randomly inserted into the acrylic molds. They were covered with a polyester matrix and then a glass microscope slide. The materials were pressed for 30 seconds by a load of 500 g to both remove excess material and form parallel planar surfaces. The

TABLE 1. PACKABLE RESIN-BASED COMPOSITES AND BLEACHING AGENT USED.

Material	Batch No.	Manufacturer	Basic Composition*
Fill Magic condensable	XPZ, XPW, XPB	Vigodent, Rio de Janeiro, Brazil	Dimethacrylates of bisphenol A (BIS-GMA, BIS-EMA, TEGDMA, UEDMA), 60% (wt) barium strontium silicate glass, silica, fluoride
Alert	0085, 0086, 0088	Jeneric Pentron Clinical Technologies, Wallingford, CT, USA	Functional dimethacrylates of ethoxylated bisphenol A polycarbonate resins, photoinitiator, amine accelerator, ultraviolet absorber, silane-treated barium boroaluminosilicate glass, silica, inorganic pigments, and small amounts of aluminum oxide
Definite	009, 0012, 0013, 0017	Degussa, Hanau, Germany	68% (wt) barium glass (barium oxide), 5% microparticulated silica, 3% modified apatite, pigments, 1% initiators, 23% ormocer resinous matrix
Review	00R, 00M	SS White, Rio de Janeiro, Brazil	10% carbamide peroxide, carbopol, propylene glycol, mint flavor, distilled water, triethanolamine

BIS-EMA = bisphenol A ethyl methacrylate; BIS-GMA = bisphenol A glycidyl methacrylate; TEGDMA = tetraethylene glycol dimethacrylate; UEDMA = urethane dimethacrylate.
*As disclosed by the manufacturers.

load and the glass microscope slide were removed, and the top surface of each specimen was light cured for 40 seconds with a light activation unit (Optilux 500, Demetron Prod., São Paulo, Brazil). The light intensity ranged from 595 to 605 mW/cm^2. Finally, the specimens were stored in a humid environment at 37°C for 24 hours.

Exposure to the Superficial Treatment

The specimens were exposed to the 10% carbamide peroxide bleaching agent for 6 h/d for 3 weeks.[8,21] During the remaining time (18 h), they were stored in individual containers with 2 mL of artificial saliva, consisting of a remineralization solution proposed by Krasse.[34]

For each specimen, 0.02 mL of bleaching material was applied to the surface, after which the samples were stored at 37°C in 100% relative humidity for 6 hours. Next, the specimens were washed thoroughly under running, distilled, deionized water for 5 seconds and then stored in 2 mL of artificial saliva during the remaining time. These procedures were repeated for 3 weeks, with the storage media being changed daily.

The control specimens remained immersed in 2 mL of artificial saliva for the same 3-week period, during which time the storage media was also changed daily.

Surface Roughness and Microhardness Tests

Surface roughness measurements were performed after the exposure of the specimens to the bleaching agent (experimental group) or immersion in artificial saliva (control group) for 3 weeks. To record roughness, three measurements were taken on the surface of the materials at different locations in each direction—parallel, perpendicular, and oblique—amounting to six tracings per sample. The needle moved at a constant speed of 1.0 mm/s, and the cutoff value (λc) was set at 0.250 mm. The average roughness (Ra) was sequentially measured by using a surface profiler (Surf Corder SE 1700, Kozaka Corp, Tokyo, Japan). *Ra* is the arithmetic average value of all absolute distances of the roughness profile from the centerline within the measuring length:

$$Ra = \frac{1}{lm}\int_0^{lm} |f(x)|dx \approx \frac{1}{n}\sum_{i=1}^{n}|f(xi)|$$

A Knoop microhardness testing machine (Future Tech—FM1e, Tokyo, Japan) was used to perform five random indentations on the top surface of each specimen with a load of 25 g applied for 20 seconds.

Statistical Analysis

For each specimen, averages of the three roughness measurements and the five Knoop hardness numbers were taken accordingly. ANOVA was applied, and the Tukey test ($\alpha = .05$) was used to identify differences in means for roughness and microhardness values.

RESULTS

ANOVA did not show significant differences in average roughnesses among the condensable composite resins evaluated ($p = .18$); nevertheless, differences were found regarding surface treatment ($p < .01$). The Tukey test showed that the condensable composite resins submitted to the treatment with 10% carbamide peroxide bleaching agents became rougher than the control group. Table 2 shows the average roughnesses and SDs of the materials submitted to the experimental and control groups and the results of the Tukey test at a 5% level of significance; Figure 1 shows the average roughnesses for the experimental and control groups.

For the microhardness tests, ANOVA showed significant differences among materials ($p < .0001$), but there were no differences for the surface treatment. Alert showed the highest microhardness values followed by Definite and Fill Magic condensable based on the results of the Tukey test at a 5% level of significance. Table 3 shows the microhardness means and SDs of the materials collected from the experimental and control groups and the results of the Tukey test. Figure 2 shows the microhardness mean for each material of the experimental and control groups.

TABLE 2. AVERAGE ROUGHNESS AND SD OF EACH OF THE PACKABLE COMPOSITES SUBMITTED TO THE EXPERIMENTAL AND CONTROL GROUPS.*

	Experimental Group		Control Group	
Material	Ra† (µm)	SD	Ra† (µm)	SD
Fill Magic	0.0795^{Aa}	0.0080	0.0705^{Ba}	0.0068
Alert	0.0761^{Aa}	0.0054	0.0711^{Ba}	0.0077
Definite	0.0734^{Aa}	0.0053	0.0697^{Ba}	0.0046

*Those in experimental group underwent bleaching. Those in the control group were stored in artificial saliva.

†Different letters indicate significant statistical differences with a $p < .05$, uppercase letters within each line and lowercase letters within each column.

Ra = average roughness.

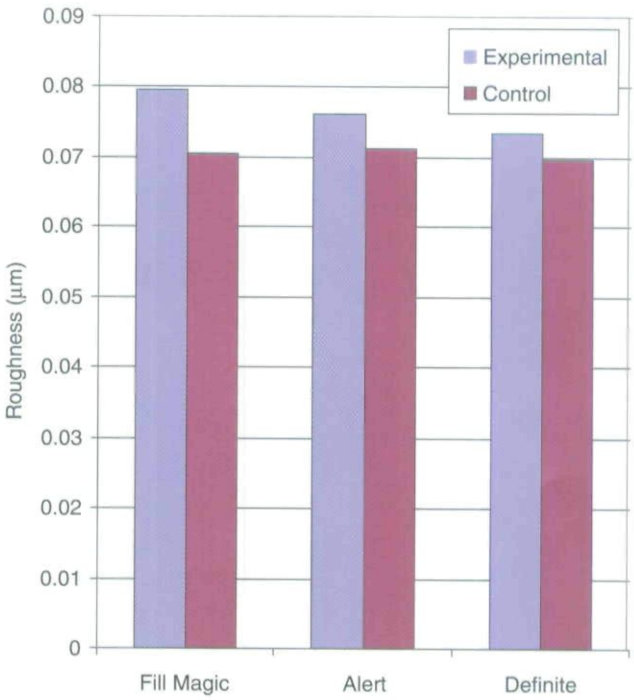

Figure 1. Average roughnesses in the experimental and control groups.

TABLE 3. MICROHARDNESS MEAN AND SD OF EACH OF THE PACKABLE COMPOSITES SUBMITTED TO THE EXPERIMENTAL AND CONTROL GROUPS.*

	Experimental Group		Control Group	
Material	KHN†	SD	KHN†	SD
Fill Magic	40.10^{Ab}	3.74	43.05^{Ab}	8.15
Alert	53.02^{Aa}	5.26	58.94^{Aa}	10.01
Definite	47.97^{Ab}	7.13	44.32^{Ab}	6.05

*Those in experimental group underwent bleaching. Those in the control group were stored in artificial saliva.

†Different letters indicate significant statistical differences with a $p < .05$, uppercase letters within each line and lowercase letters within each column.

KHN = Knoop hardness number.

DISCUSSION

Changes in the chemical or morphologic structure of the surface of restorative materials must be of concern when using bleaching techniques as a treatment for whitening teeth. Although 10% carbamide peroxide has been shown to be a safe and effective material with ADA approval,[3] there is a need for a prolonged contact of the agent with the dental structure to allow the oxidation process to take place.[2] This contact also occurs between the agent and preexisting restorations, with the latter being exposed to the same conditions.

This study showed the effects of a 3-week regimen with a 10% carbamide peroxide agent acting on surface roughness and microhardness of condensable composite resins. Although some studies have been conducted to evaluate the surface of a variety of restorative materials such as amalgam,[27–29] glass ionomer–based materials,[35,36] and composite resins,[22–26,37] no reports are available describing the behavior of condensable composite resins in response to bleaching.

Our results show that the condensable composite resins exhibit rougher surfaces when a 10% carbamide peroxide agent is applied when compared with specimens that were immersed in artificial saliva throughout the study. Although Garcia-Godoy and Garcia-Godoy reported no significant effects on the surface roughness of microfilled anterior and hybrid composite resins,[25] Cooley and Burger, Bailey and Swift, and Cehreli and colleagues showed an increase in surface roughness of microfilled and hybrid composites.[22,23,35] Although Bailey and Swift noted some softening of both hybrid and microfilled composite surfaces, this effect was minimal and not statistically significant.[23] These variations may suggest that some composite resins are more susceptible to alterations, or that different brands or bleaching appli-

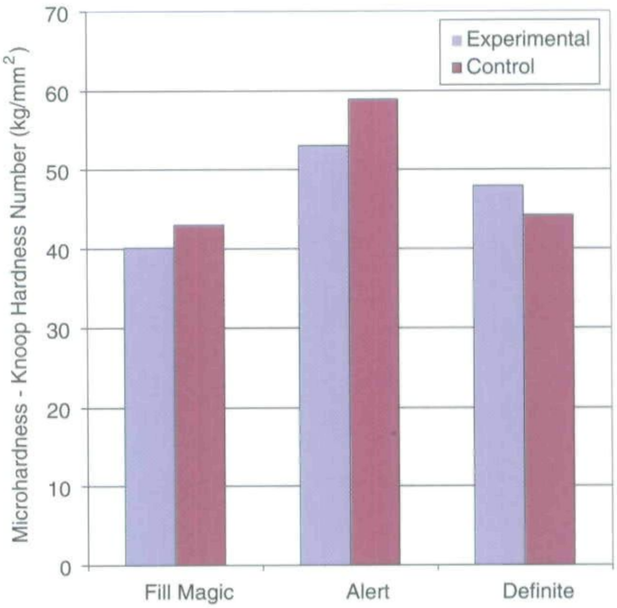

Figure 2. Microhardness means of the experimental and control groups.

cations may be more likely to cause changes in roughness.

Softening of resin-based composites is believed to occur chemically in vivo, which contributes to the wear of the resin in stress-bearing and nonstress-bearing areas. Composite matrices composed of bisphenol A glycidyl methacrylate resin polymers can be softened by chemicals with similar solubility parameters.[38] One of the possible causes of the rougher surfaces presented by the condensable composite resins tested is the pH of the agent since it can also affect the physical and chemical structure of the enamel.[2] Some studies reported that the pH of these agents ranges from 4.6 to 7.4,[10,12,19,21] and that the acidic solutions could contribute to enamel or dentin demineralization.[4,5,8] Although the pH of the agents seems to increase after 15 minutes' exposure,[21] roughening could be explained by the prolonged contact time between material and bleaching agent.

Even though the surface roughness of condensable resins was affected by daily applications of 10% carbamide peroxide, this regimen seems to not affect their surface microhardness. Other studies have reported an increase or a decrease in microhardness of composite resins.[22,23,26] This shows that the effect of carbamide peroxide gels may depend on composite material. However, our results seem to agree with those of Garcia-Godoy and Garcia-Godoy,[25] Nathoo and colleagues,[24] and Campos and colleagues,[37] which showed no changes in microhardness when a microfilled anterior composite and hybrid composite resins were evaluated. On the other hand, there were differences in hardness values among the condensable resins used: Alert showed the highest microhardness values followed by Definite and Fill Magic condensable. These differences could be related to the inorganic composition of each material (see Table 1). Definite is considered an ormocer (a material that consists of prepolymerized ceramic particles in an organic matrix that decreases the polymerization contraction), whereas Alert shows higher amounts of inorganic components when compared with the other materials evaluated. Manhart and colleagues also found that Alert presented the highest microhardness values when compared with values from three other packable resins, which led to the conclusion that this material is rather inhomogeneous in terms of mechanical and physical data.[33]

CONCLUSIONS

The findings of this study showed that a 10% carbamide peroxide agent can affect the surface roughness of condensable composite resins after a 3-week bleaching regimen. However, the surface microhardness is not affected, despite the existing differences among the materials evaluated with respect to their composition.

It must be noted, however, that the findings exhibited in this study do not necessarily bear clinical significance.

DISCLOSURE AND ACKNOWLEDGMENTS

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COMMENTARY

EFFECTS OF A 10% CARBAMIDE PEROXIDE BLEACHING AGENT ON ROUGHNESS AND MICROHARDNESS OF PACKABLE COMPOSITE RESINS

Jeffrey Y. Thompson, PhD*

The authors have investigated the effect of a lower-concentration (10%), commercially available carbamide peroxide bleaching agent on the in vitro surface roughness and microhardness of three packable composite restorative materials. Bleaching agent–induced degradation of dental composites has been a popular topic of several laboratory investigations published over the past few years.[1] The effects of numerous bleaching agents, such as carbamide peroxide or sodium perborate, over a wide range of compositions (3–35%) on a variety of composite properties and characteristics, including surface roughness, hardness, strength, and discoloration, have been evaluated. In the study presented here, a mild effect was observed on the examined properties of the tested packable composite materials. However, in many studies a significant deleterious effect has been observed after prolonged in vitro exposure. In some cases, changes in color, hardness, and surface roughness were extreme. Yet no reports exist in the scientific literature indicating any negative impact on composite restorations exposed to bleaching agents in vivo, even after 10-plus years of widespread clinical use.

Why this discrepancy? The static versus dynamic nature of the two different environments easily explains this difference. In vitro experiments are generally conducted in closed systems, in which exposure doses and times are artificially exaggerated, leading to results that have limited clinical relevance. Even in studies where great care is taken to accurately simulate intraoral conditions, replication of the complex in vivo chemistry and kinetics is difficult, if not impossible. This is not to say that in vitro studies, such as the one presented here, are without value. One might think of the exposure evaluated in a laboratory setting as a "worst case scenario," providing guidance as to which bleaching agents or therapies might have the greatest potential impact on a composite restoration.

In summary, although scientifically interesting, in vitro evaluations of the effect of bleaching agents on the properties and characteristics of dental composite materials likely offer limited insight to in vivo responses of the same materials.

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