Effects of Carbamide Peroxide Bleaching Gel on Color of Silorane- and Methacrylate-based Resin Composites

Original Article

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Abstract

Introdouction:
Bleaching has become a common treatment for improving the appearance of natural teeth. However, the need to protect dental restorations from bleaching agent exposure is inevitable, as these agents may change the color of restorative materials by oxidation. Filtek P90 composite resin has recently been introduced with the aim of decreasing polymerization shrinkage. The purpose of this study was to compare the color changes of silorane- and methacrylate-based resin composites after exposure to various carbamide peroxide regimens.

Materials and methods:
Sixty-four disk-shaped specimens (10 × 2 mm) of a microhybrid composite, Z250, and a silorane-based composite, P90, were prepared and divided into four subgroups (n = 8). An unbleached group was used as a control, while the remaining specimens in the three subgroups were bleached with 10%, 16%, and 22% carbamide peroxide for 14 days. The color was measured with a spectrophotometer using Commission International de l'Eclairage L*, a*, and b* color scale. The data were analyzed using ANOVA, the t-test, and Tukey's HSD test.

Results:
Color differences between bleaching and baseline values (ΔE) were <3.3 for all the groups. Z250 and P90 resin composites showed color changes after bleaching with 10%, 16%, and 22% carbamide peroxide, but the changes were insignificant (Z250: $p = 0.323$, P90: $p = 0.136$).

Conclusion:
The color changes were not clinically evident in the sample groups. For both the Z250 and P90 specimens, no statistically significant differences in color were noted

Key words:
•Composite Resins •Methacrylates •Silorane Resins •carbamide peroxide •Color.

Introduction

Color stability is considered an important factor in the success of an esthetic restoration. To maintain excellent esthetic properties, tooth-colored restorative materials should have good color stability. Both extrinsic and intrinsic factors contribute to color changes in restorative materials.(1) Three types of discolorations are generally described with restorative materials: external discoloration due to the accumulation of plaque and surface stains; surface or sub-surface color alteration implying superficial degradation or slight penetration; and the reaction of staining agents with the superficial layer of composite resins, along with intrinsic discoloration due to physicochemical reactions in the deeper portion of the restoration. Moreover, the structure of the composite resin and the characteristics of its particles have a direct influence on the susceptibility to extrinsic staining.(2)

Bleaching is an effective and conservative esthetic treatment for removing intrinsic and extrinsic stains from teeth. The bleaching agent usually contains peroxide (in the form of carbamide and hydrogen peroxide) in gel or liquid form. The agent is placed in contact with the teeth for bleaching times that vary depending on the formulation of the material used. The bleaching effects are directly related to the exposure time and concentration of active bleaching ingredients, types of stain, and its etiology.(3)

Patients seeking bleaching treatment may have teeth restored with different kinds of esthetic restorative materials.(4) These bleaching agents have been found to have a profound influence on the color behavior of tooth-colored restorations and may even deteriorate them.(5) In the case of dental composite resins, bleaching agents may have an influence on resin matrix, filler, or both. In particular, the organic matrices of resin composites are prone to chemical alterations induced by the acidic component of bleaching agents. This may then compromise the color matching of resin composite restorations to the adjacent tooth structure, necessitating their replacement.(3)

A new monomer system called silorane has been developed with the aim of reducing polymerization shrinkage. Silorane includes a cationic ring-opening hybrid monomer system that contains both siloxane and oxirane structural moieties. The results of studies on the color change effects of bleaching agents on restorative materials have been controversial. Some studies have demonstrated that the effects of bleaching treatment with peroxide on the color of tooth-colored restorations are not clinically visible,(4,6) while others have reported a significant impact on composite restorations. These conflicting results are associated with resin matrix volume and the type of filler used.(7) Hashemi Kamangar et al. observed that different concentrations of bleaching agents have no significant effects on the color of silorane and methacrylate-based composites.(8)

There are limited data in the literature related to the color change effects of bleaching procedures on silorane-based composites. Therefore, this study examined the color stability of a silorane-based resin composite after exposure to various concentrations of carbamide peroxide and compared the results from a methacrylate-based resin composite.

Materials and Methods

The materials used in this study, their composition, and their manufacturers are listed in table1. The materials included a methacrylate-based composite, Z250 (3M, ESPE, USA), a silorane-based composite, P90 (3M, ESPE, USA), and the bleaching materials, which included Whiteness Perfect 10%, 16%, and 22% (FGM, Joinville, SC, Brazil). For each type of composite, 32 disk-shaped specimens were made using customized Teflon molds (10 mm diameter, 2 mm thickness). All the chosen resin composites had shade A2 for their coloration. The composite was packed with condenser into the mold. The material was covered with a Mylar strip (3M Flip-Frame; 3M Visual Systems Division, Austin, TX, USA) and a glass microscope slide, and the resin composites were polymerized using an Astralis7 curing light (Ivoclar Vivadent, Liechtenstein), according to the manufacturers' instructions. This light source had an intensity of 750 mW/cm², and the curing time was 20 seconds. Following removal from the molds, the specimens were light-cured for 20 seconds. The top surfaces of the specimens were polished using medium, fine, and superfine discs (Sof-Lex; 3M, ESPE, USA). All the specimens were stored in distilled water for 24 hours at 37°C.

Table 1: Restorative materials used in this study

Manufacturer	Content	Type	Material
Filtek Z250	Microhybrid methacrylate-based composite	Bis-GMA, Bis-EMA, UDMA, TEGDMA filler: zirconia, silica (78% weight) (60% volume) (size 0.01–3.5µm)	3M ESPE, St. Paul, MN, USA
Filtek P90	Silorane-based composite (microhybrid)	Silorane resin, initiating system: comphorquinone, iodonium salt, electron donor quartz filler, yttrium fluoride (76% weight, 55% volume, size: 0.04–1.7 m) stabilizers, pigments	3M ESPE, St. Paul, MN, USA
Whiteness Perfect 10%, 16%, and 22%	carbamide peroxide agent	10%, 16%, and 22% CP, carbopol, glycol, water, potassium nitrate, sodium fluoride	FGM, Joinville, SC, Brazil

Bleaching procedure:

For each composite group, specimens were randomly divided into four subgroups (n = 8):

subgroup 1: specimens were immersed in Whiteness Perfect (10% carbamide peroxide gel) for 4 hours for 14 consecutive days.

subgroup 2: specimens were immersed in Whiteness Perfect (16% carbamide peroxide gel) for 3 hours for 14 consecutive days.

subgroup 3: specimens were immersed in Whiteness Perfect (22% carbamide peroxide gel) for 1 hour for 14 consecutive days.

subgroup 4: for the control group, specimens were immersed in distilled water for 14 consecutive days at 37°C.

The application of bleaching agents was performed according to the manufacturer's instructions.During the treatment period, the specimens were kept at room temperature. Each day after the active treatment, the specimens were rinsed with tap water for one minute to remove the bleaching agents, blotted dry, and stored in distilled water at 37°C.

Color assessment:

A Vita Easyshade compact spectrophotometer (Vident, USA) was used to record the color variables according to the Commission International de I'Eclairage L*, a*, b* (CIELAB) system. The CIELAB color system is a method recommended for dental purposes and characterizes a color based on human perception.

This system designates a color according to three spatial coordinates: L*, a*, and b*, which represent the brightness (value) of a shade, the amount of red-green color, and the amount of yellow-blue color, respectively. The L* coordinates are located along a vertical axis that ranges from 0 (completely black) to 100 (completely white);[9-13] a* uses positive values (+a*) to denote red colors and negative values (-a*) to denote green colors; and b* depicts yellow color with positive values (+b*) and blue color using negative values (-b*).[2] Before each measurement session, the instrument was calibrated according to the manufacturer's recommendations. Color measurement was conducted on the top surface of each specimen against a white background. Each specimen was measured three times in three different parts, and the average baseline values of L*, a*, and b* were calculated, both before bleaching (L1, a1, and b1) . and after that (L2, a2, and b2). The magnitude of total color difference (ΔE*) was calculated using the following equation:

$$\Delta E^* = [(\Delta L^*)2 + (\Delta a^*)2 + (\Delta b^*)2]^{1/2}$$

$\Delta E < 3.3$ was considered visually inappreciable and clinically acceptable.[14] After data collection, the mean values and standard deviations were calculated by using the SPSS 26 statistical software program. ANOVA, the t-test, and Tukey's HSD test were applied to determine whether significant differences existed among the groups. All statistical analyses were conducted using a significance level of $p < 0.05$.

Results

The ΔL, Δa, Δb, and ΔE values for all the materials are presented in Table. ΔE: All the bleached specimens showed values of $\Delta E < 3.3$. Therefore, the color change was not clinically observed within groups (Figure 1). For both the Z250 and P90 specimens, no statistically significant differences were noted ($p = 0.378$). The differences between all subgroups and concentrations of bleaching agents were not significant (Z250: $p = 0.323$, P90: $p = 0.136$).

a*: For the a* values, significant increases were observed for the subgroups of Z250 after bleaching (a2) ($p = 0.011$). Therefore, the mean value of Δa was significant for Z250 (p = 0.039). (Figure 2)

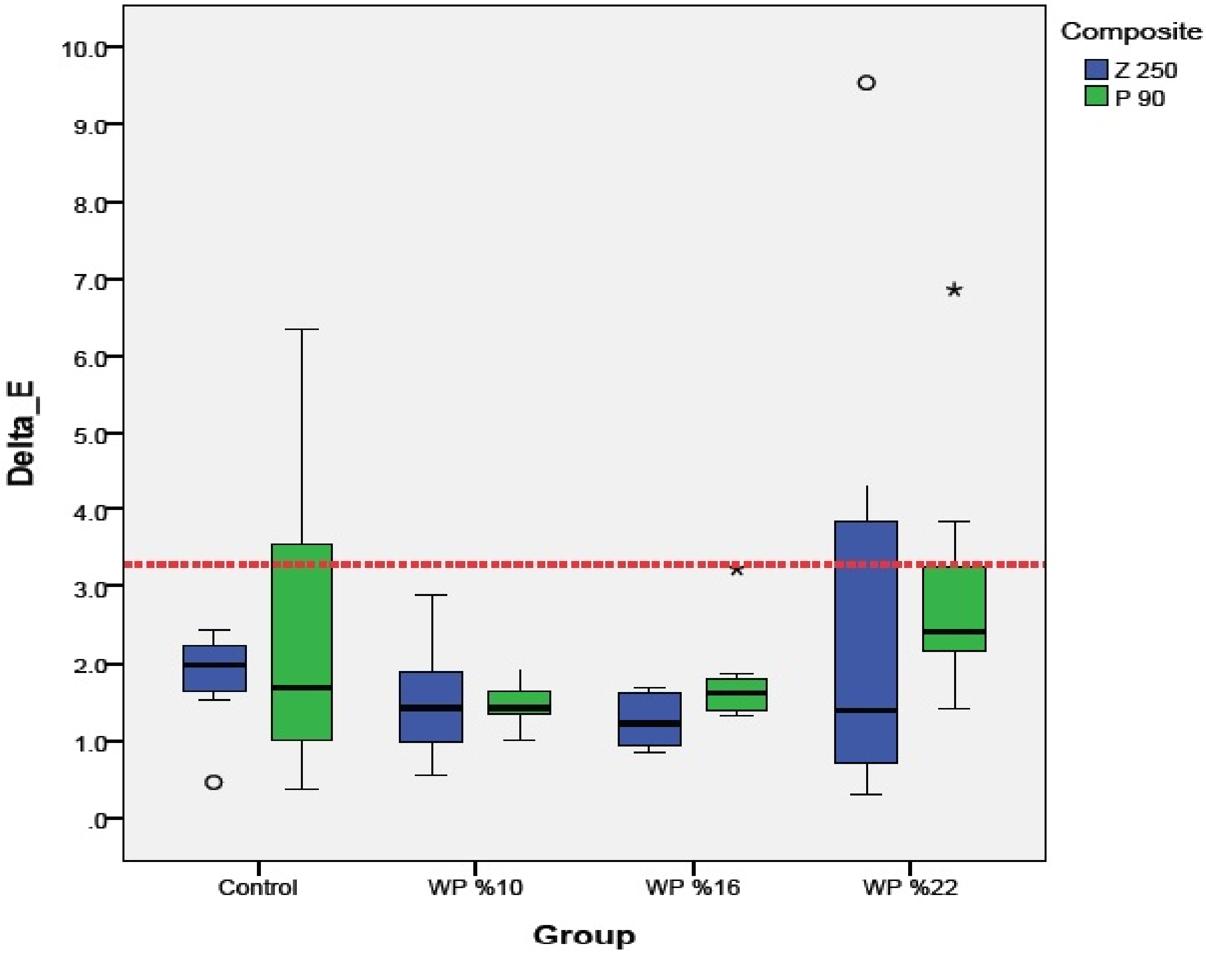

Figure 1: Mean ΔE values for all Groups

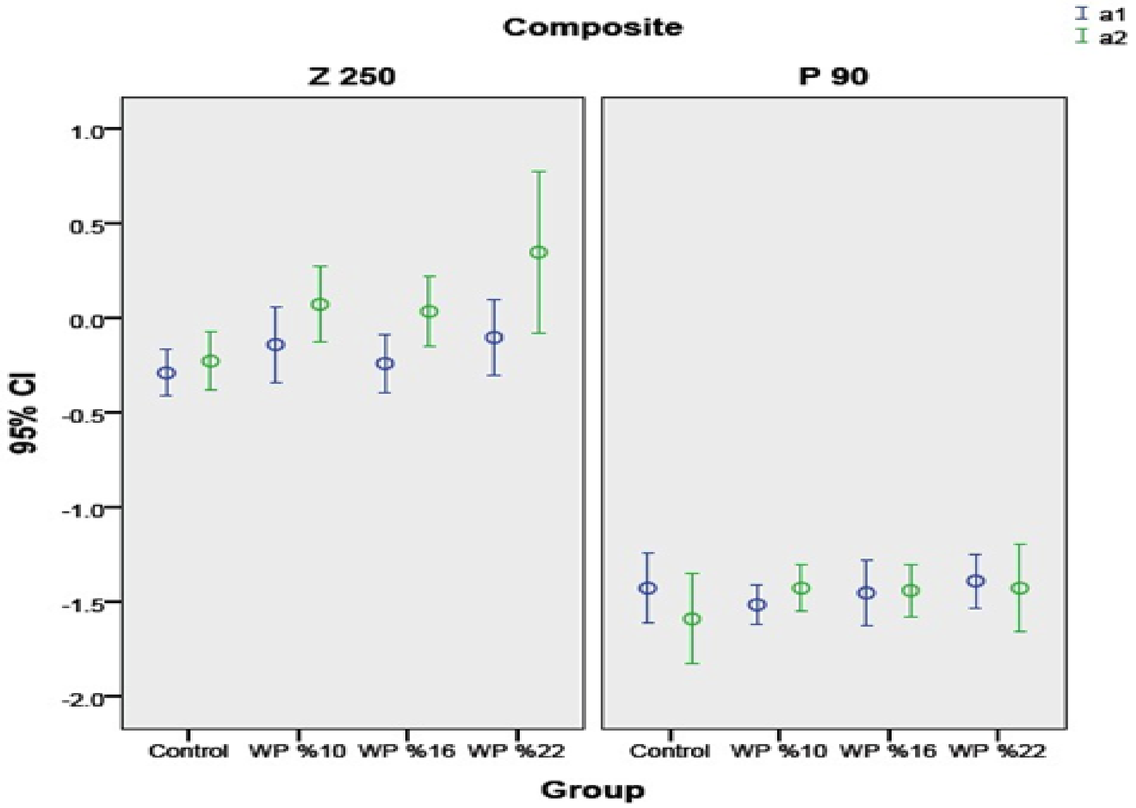

Figure 2: Comparison of a* value before and after bleaching

b*: For the b* values, significant decreases were observed for the subgroups of Z250 and P90 after bleaching (b2) ($p = 0.006$, $p = 0.008$, respectively). Therefore, the mean values of Δb were significant for both Z250 and P90 ($p = 0.004$, $p = 0.003$, respectively). (Figure 3)

L*: There were no significant differences between groups and subgroups for Z250 or P90. (Figure 4)

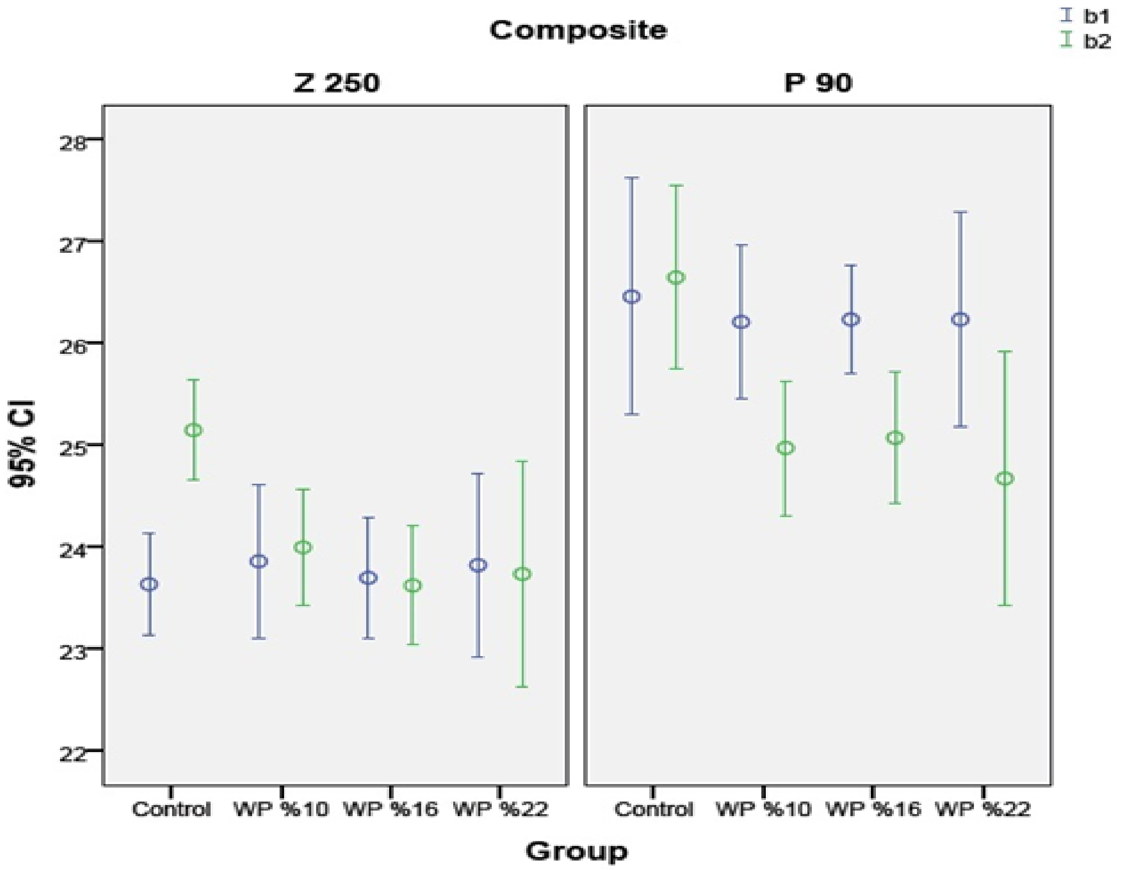

Figure 3: Comparison of b* value before and after bleaching

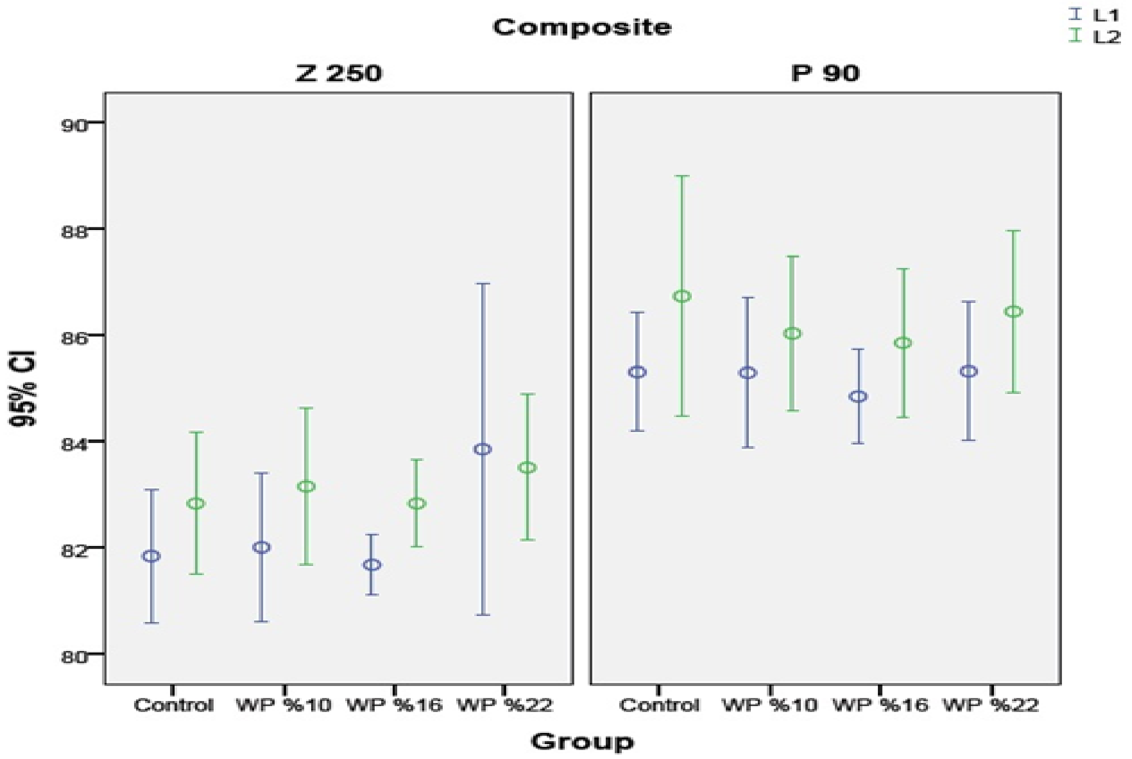

Figure 4: Comparison of L* value before and after bleaching

There were also no statistically significant differences found between control groups for any concentration of bleaching agents. (Table 3)

Table 2: Mean and standard deviation (±sd) Δa, Δb, ΔL, ΔE values for all experimental groups.

Groups	Parameters	Δa	Δb	ΔL	ΔE
Z250	Control	0.06 ± 0.11	1.51 ± 0.57	0.98 ± 0.41	1.83 ± 0.63
	WP 10%	0.21 ± 0.27	0.13 ± 0.83	1.15 ± 0.87	1.50 ± 0.73
	WP 16%	0.27 ± 0.13	-0.07 ± 0.39	1.15 ± 0.40	1.26 ± 0.34
	WP 22%	0.45 ± 0.38	-0.08 ± 1.64	-0.35 ± 3.84	2.71 ± 3.09
	.sig	0.039	0.008	0.379	0.323
P90	Control	-0.16 ± 0.30	0.18 ± 0.79	1.42 ± 2.73	2.40 ± 1.99
	WP 10%	0.08 ± 0.06	-1.23 ± 0.17	0.73 ± 0.37	1.46 ± 0.26
	WP 16%	0.01 ± 0.08	-1.16 ± 0.31	1.01 ± 1.07	1.77 ± 0.62
	WP 22%	-0.03 ± 0.30	-1.56 ± 1.60	1.12 ± 2.50	2.99 ± 1.70
	.sig	0.170	0.003	0.914	0.136

Table 3: comparison of ΔE of group control with other groups

Composite	Groups		p. value
Z250	Control	WP 10%	0.97
		WP 16%	0.89
		WP 22%	0.70
P90	Control	WP 10%	0.52
		WP 16%	0.78
		WP 22%	0.81

Discussion

Color plays an important role in ensuring optimum esthetics. The growing desire for improved esthetics among patients has created greater demand for restorative materials with excellent esthetic properties. However, to be considered clinically acceptable, the materials must not only provide an initial shade match in a restored tooth, but also maintain an esthetic appearance over the years. For these reasons, the present study evaluated the color stability of recently introduced resin composites by examining their color changes following exposure to carbamide peroxide.

Discoloration can be evaluated using visual or instrumental techniques. Instrumental techniques for color measurement include colorimetry, spectrophotometry, and digital image analysis. Of these, spectrophotometry has been reported to be a reliable technique in dental material studies.[15] The present study measured the colors of the resin composites with a spectrophotometer using the CIELAB system.

The parameter ΔE indicates the relative color changes that an investigator can perceive in the materials before and after treatment or between intervals. The minimum color difference considered to be visible by the human eye is ΔE = 0.3–0.5. There is no coordination between the colors of existing restorations and natural teeth in the range of ΔE = 1.1–2.1, but this range is considered clinically acceptable,[16,17] whereas values of $\Delta E \geq 3.3$ are considered appreciable by non-skilled persons, and are therefore not clinically acceptable.[18]

After the application of bleaching agents, tooth whitening results from the oxidation of organic substances by free radicals. The oxidation/reduction process changes the chemical structures of the tooth's organic compounds, creating color change.[19,20]

There are limited data in literature concerning the effects of bleaching systems on composite resins. Peroxides could induce oxidative cleavage of polymer chains.[21-23] Free peroxyl radicals (HO2-) are eventually changed into water and oxygen, accelerating the process of hydrolytic degradation and the discoloration of composite resins. Free radicals induced by peroxides may also impact the resin-filler interface and cause filler-matrix debonding. Microscopic cracks are formed, resulting in surface roughness and leading to the diffusion of the bleaching agent.[24,25]

Regarding the amount of filler, it has been reported that resin composites with a lower amount of inorganic fillers showed more color changes because greater resin matrix volumes allow greater water sorption.[26]

It has been reported that two key factors determine the overall whitening efficacy of peroxide-containing products: peroxide concentration and application duration.(27) To determine the potential color changes for two resin composites after bleaching, 10%, 16%, and 22% carbamide peroxide were tested as bleaching agents using different application times (Tables 1 and 2).

In the present study, the application times for the bleaching procedure varied by concentration of carbamide peroxide. In accordance with the manufacturer's information, the application time was decreased for 22% carbamide peroxide.

Upon examining the chromatic values of the bleached resin composites, it could be seen that the Z250 and P90 resin composites showed an increase in brightness, based on L* values, after bleaching for all bleach concentrations. A heightened increase was observed following the use of 22% carbamide peroxide, although it was not significant.

For the a* values, a significant increase of Δa was observed for the Z250 composite. This contributed to a red shade observed in the specimens. For the b* values, a significant decrease of Δb was observed for both Z250 and P90 composites. This indicated a decrease in yellow among the specimens.

These findings coincide with the results of de Andrade et al.,(28) Randa Hafez et al.,(29) and silva Costa et al.,(4) which found negligible results for the effects of tooth-whitening agents on the color of dental composite resins. Also, there was no variation in color change according to the type of composite resin used.

Andrade et al. found that 10% and 16%, carbamide peroxide produced no significant color change effects on nanofilled resin composite.(28) Costa et al. reported that 7% and 35% hydrogen peroxide and 10% and 35% carbamide peroxide had no significant effects on the color of nanofilled composite, with the exception of the most highly concentrated bleaching agent. It is conceivable that the storage of composite specimens in saliva might have reduced the effects of bleaching agents through the formation of a surface-protectant layer on the restorative material.(4) Hafez et al. found that none of the bleaching systems tested in that study notably changed the color of composites, although the type of bleaching system used was found to have a significant effect on roughness.(29) These findings coincide with the results of Hashemi Kamangar et al., in a study that compared the color changes of silorane and methacrylate-based resin composites that were exposed to various solutions.(8)

However, other studies reported significant difference in the color change after bleaching.

Torres et al. demonstrated that bleaching with 35% hydrogen peroxide resulted in greater color variations than 20% hydrogen peroxide, but no differences were detected between the use of 20% hydrogen peroxide and the control group. This leads to the assumption that the concentration of hydrogen peroxide used in bleaching can influence the degree of color change. Moreover, the composite resin matrix's degree of polymerization may impact color stability, because monomers would be degraded by bleaching agents.(30) In addition, Andrade et al. reported a color change effect from 35% hydrogen peroxide applied to a nanofilled resin composite. The data from this study may be attributed to a higher proportion of hydrogen and the more acidic pH of the 35% bleaching agent.(28)

The discrepancies between these studies may be explained by the differences in experimental methodologies, bleaching agent concentration, formulation, application time of bleaching agents, and restorative materials used.

It is suggested that following the bleaching processes, the composite properties should be evaluated and in the event of a significant change, the patient should be informed of a possible need to replace existing composite restorations.

Conclusion

in this study, the different concentrations of carbamide peroxide did not change the color of the methacrylate- and silorance-based composites appriciably.

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