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ORIGINAL ARTICLE

Color Stability of Different Composite Resin Materials Bleached with Three Bleaching Agents

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Abstract

The aim of this study was to compare the color stability of 3 proprietary carbamide peroxide bleaching agents on composite resins. Specimens were prepared with a polytetrafluoroethylene plate. After initial color measurements, bleaching agents were applied to each composite resin for 2 weeks. Second color measurements were made. Tested specimens including control group were immersed into distilled water for a - 4 month follow-up period. Third and fourth color measurements were made again after 2 weeks and 4 months of follow-up period. Friedman ($p<.01$), Kruskal Wallis ($p<.05$) and Wilcoxon Tests were used for statistically evaluation. The most significant color change was seen at the Ormocer group ($p<.011$). The most significant color change ΔE values were obtained for the Ormocer-Voco group and color changes remained stable after 4 months of immersion in distilled water. Slight color changes values were obtained for nanohybrid and fine particle hybrid composite resins.

Keywords: Bleaching, restorative materials, color stability.

Introduction

Tooth bleaching has been reported in the literature as an esthetic treatment option as early as 1898 (1). The nightguard bleaching technique has been in use since 1989 (2). The night guard vital bleaching agent is commercially available in the form of various products with different carbamide peroxide content. The basic clinical technique involves the use of a soft, plastic, night guard-styled prosthesis (3). Carbamide peroxide solutions are very unstable and immediately dissociate into their constituent parts on contact with tissue or saliva. The 10-16 % carbamide peroxide solution dissociates into 3-5 % hydrogen peroxide and 7-10 % urea. The hydrogen peroxide further degrades into oxygen and water, while the urea degrades into ammonia and carbon dioxide (3). Hydrogen peroxide decomposes in aqueous solutions to hydroxyl radicals which are highly reactive. Because radicals lack one electron, they are extremely electrophilic and unstable and will attack most other organic molecules to achieve stability generating other radicals (4). Treatment times for the night guard vital bleaching technique vary, and effectiveness of the bleach method depends on the time the patient wears the bleaching night guard (1).

There are several reports on the effect of bleaching agents on the color of composite resins (5-10). Monaghan et al (5) reported that Rembrandt Lighten and White and Brite bleaching agents created slight color changes of the composite resin restorative material. Monaghan et al (6) also observed significant color difference when the tested composite restorative materials were exposed to the superoxyl bleaching solution after treatment with 37% $H3O4$. Cullen et al (7) found that microfilled composite resin color changes occurred during the bleaching procedure but, bleached composite resins returned to their original color after a week. Fay et al (8) reported that bleaching agents remove stains from composite resins and hybrid ionomer. Canay and Çehreli (9) claimed that 10% HP was more likely to cause color change of composite resins compared to10% CP. Vilalta et al. (10) were stained nano composite and microfillled composite in different staining solutions and after the staining processes, they bleached the composites and reported that the color of the stained specimens returned to baseline measurement for all group tested, even after discolorations due to staining. In conclusion, application of 10% hydrogen peroxide or heated 30% hydrogen peroxide resulted in composite resin color changes for the different materials and shades tested (6, 9) In contrast, the use of 10% carbamide peroxide resulted in color changes of composite of less than 2 ΔE units (5, 9).

A number of methods are available for measuring the color of dental materials and teeth. Shade guides (11, 12), visual evaluation (11) or photographs (11) are useful for color evaluation, however, these rely on subjective options and which have been shown to be unreliable. The colorimetric instruments such as colorimeters

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or spectrophotometers yield numeric values and better reability are more than the others (5, 13) Another approach for measuring tooth color is by using non-contact camera-based digital imaging and analysis systems (12). The CIELab system is an approximately uniform color space that coordinates for lightness, namely white-black (L*), redness-greenness (a*) and yellowness-blueness (b*) (14). Color difference (DE) was calculated from the mean DL*, Da* and Db* values for each specimen. The quantitative evaluation of color difference (DE) with a colorimeter confers advantages such as repeatability, sensitivity and objectivity (14, 15). A ΔE of more than 1 is clinically noticeable under optimal viewing conditions by trained observers (16). Johnston and Kao (17) reported that, if ΔE is less than 1, this chromatic value deemed to be slight, under clinical conditions in the mouth, DE color differences have been reported to be relevant and perceptible only when higher than 3.3 (18) or 3.6 (17). The authors identified no information in the literature about the color stability of bleached composite resins.

Esthetic restorative materials have gained great popularity due to the esthetic demands of patients not only in the anterior region but also the posterior region (19). Discoloration of composite resins has been demonstrated during service intraorally (20). New generation of tooth colored restorative materials have been introduced to the market (21). Ormocers, organically modified ceramics, consist of a long ”backbone” of silicon instead of carbon (22). Alkoxysilanes as sol-gel precursors have been developed for synthesis of inorganic-organic copolymer ormocer composites as dental restorative materials. The alkoxysilyl groups of the silane allow the formation of an inorganic Si-O-Si network by hydrolysis and polycondensation reactions, and the (meth) acrylate groups are available for photochemically induced organic polymerization (23). After incorporation of filler particles, the ormocer composites can be manipulated by the dentist like a hybrid composite (22). Nanohybride composite resin, are claimed to have improved properties in both aesthetics and mechanical performance. The superior mechanical properties like high flexural strength, low abrasion, low polymerization shrinkage and resistance to fracture are attributed to the high-filler load of these materials because of the small size the fillers possess (24). The fine particle hybrid composite resin presents diurethane dimethacrylate (UDMA) and bisphenol –A ethoxylate dimethacrylate (bis-EMA) in its composition that are considered high molecular weight resins. This results in less shrinkage, reduced aging, and slightly softer resin matrix25 The purpose of this study was to determine and compare the color stability of 3 different composite resin materials (ormocer, nanohybrid and fine particle hybrid composite) which were bleached with 3 different proprietary carbamide peroxide bleaching agents. The following null hypothesis were tested: there is no difference in color stability between the ormocer, nanohybrid and fine particle hybrid composite resin specimens bleached with different bleaching agents.

Materials and Methods

Three different composite resin materials (ormocer, nanohybrid and fine particle hybrid composite) were bleached with 3 different proprietary carbamide peroxide bleaching agents. Distilled water was used as a control group. Initial color measurements were made before the bleaching procedure. The second color measurement was made after 2 weeks of bleaching procedure then, all the specimens were replaced to the distilled water and the third and final color measurement were obtained after 2 weeks and 4 months of immersion in distilled water respectively. All the data were collected and evaluated statistically.

Three bleaching products and 3 restorative materials were chosen for this study. The materials, product names, manufacturers are listed in Table 1. For the preparations specimens the shade A3

Table 1. Materials tested

Material	Product Name	Composition	Batch Number	Manufacturer
Ormocer	Admira	Ormocer Bis-GMA, urethane dimetacrylate and triethyleneglycol dimethacrylate 78% (wt), 56%(vol) glass-ceramic SiO_2 Microfiller) 0.7µm	0905177	Voco GmbH, Cuxhaven, Germany
Nanohybrid composite resin	Grandio	Bis-GMA, dimethacrylate, urethane dimethacrylate and riethyleneglycol dimethacrylates 87% (wt), 71.4 (vol) Glass-ceramic (Microfiller) 1µm, SiO_2 (Nano-filler) 20-60nm	0840095	Voco GmbH
Fine particle hybrid composite resin	Z 250	Bis-GMA, UDMA, Bis-EMA 60% zirconium, silica 0.6µm mean particle size	1370	3M ESPE, Seefeld, Germany
17% Carbamide peroxide	Voco Perfect Bleach	Peppermint oil tromethamine	0843446	Voco GmbH
16% Carbamide peroxide	Viva Style	Glycerine Buffered polycarboxylic acid Peppermint oil	HL1034	Ivoclar Vivadent AG, Schaan, Liechtenstein
20 %Carbamide peroxide	Opalescence	Carbopol Glycerine Flavoring 3%potassium nitrate 0.11 % ion fluoride	6514	Ultradent Products Inc, South Jordan, Utah

or the shade corresponding to A3 was used for every material. 32 disc-shaped specimens from each material (96 specimens in total), 1 cm in diameter and 6-mm-in depth, were prepared in polytetrafluoroethylene plate (Gapi, Bergamo, Italy). The restorative materials were placed into the mold separately and sandwiched between 2 glass plates, using titanium nitride-coated instruments (Brilliant Esthetic Line Composite Instrument, Coltène AG, Altstätten, Switzerland). In accordance with the manufacturer's directions, specimens were polymerized for 40 seconds with a wide-tipped prismatic light-polymerizing unit (Optilux VLC 401, at 420 mW/cm$^{2;}$ Kerr Corp, Orange, Calif). The distance between the light source and specimen was standardized to 1 mm during the polymerization process. Thirty-two specimens of each restorative material were prepared. The specimens were polished with medium, fine and superfine disks (Sof-Lex; 3M ESPE, St. Paul, Minn) in a slow-speed hand piece in accordance with the manufacturer's directions and further cleaned in distilled water in an ultrasonic cleaner (Whaledent Biosonic; Coltène Whaledent Inc) for 5 minutes.

Each restorative material group was divided into 4 subgroups, 3 bleaching and 1 control, (n=8). All specimens were stored in distilled water in screw-top vials (Isolab, Wetheim, Germany) at room temperature for 24 hours before testing. Initial color measurement was performed by using CR-200 colorimeter (Minolta Co, Ramsey, NJ) before the application of bleaching agents. The colorimeter was calibrated according to the manufacturer's instructions before each measurement session. The specimens were positioned on the calibration plate of CR-200 as a standard background and 3 measurements for each specimen were performed in the same room and lighting. The mean of the readings were calculated. Then, the color change of the specimens was determined by calculating the ΔE from the L*a*b* values obtained with the colorimeter. A ΔE of more than 1 is clinically noticeable under optimal viewing conditions by trained observers16. The following formula was used (16) .

$$\Delta E= [(L_F^*- L_I^*)^2 + (a_F^*- a_I^*)^2 + (b_F^*- a_I^*)^2]^{1/2}$$

In this system, L , a* and b* represents lightness, redness-greenness, yellowness-blueness respectively. The subscript I stand for the initial value and the subscript F stands for the final value.

The bleaching procedure was performed over a period of 2 weeks (26). The specimens were immersed in the bleaching gels for an average of 8 hours per day. At the end of the bleaching procedure, the treated and control specimens were removed and washed under running distilled water for 30 seconds and placed in fresh distilled water until the next daily application (27-30).

The color measurements were repeated at the end of the second week of bleaching procedure (immediate). Then, all the specimens were immersed in the distilled water for a 4 months follow-up period. Color measurements were repeated after 2 weeks (2 weeks) and 4 months (4 months) of follow-up period and mean ΔE values of all the groups were obtained.

The statistical package NCSS 2007&PASS 2008 (Statistical Software, Utah, USA) was used to analyse the data. The data obtained was evaluated by Kruskal Wallis test, Mann Whitney U test, Friedman test and Wilcoxon test. The level of statistical significance was set at $p< .05$. (Table 2 and Table 3).

Results

Evaluation of the bleaching agents and control group in each restorative materials tested related to time period were presented in Table 2. Evaluation of the restorative materials in each bleaching agents and control group tested were shown in Table 3.

According to the table 1, in ormocer group, there were statistically significant difference between the immediate *ΔE* values of bleaching

Table 2. *ΔE* values of the bleaching agents in restorative materials tested

		Voco	**Viva**	**Opal**	**Distilled water**	^{+}p
		Mean±SD (Median)	**Mean±SD (Median)**	**Mean±SD (Median)**	**Mean±SD (Median)**	
Ormocer	**Immediate**	1.93±1.51 (1.48)	1.01±0.81 (0.79)	0.58±0.34 (0.50)	0.49±0.20 (0.46)	***0.003*****
	2 weeks	2.33±1.24 (2.24)	1.26±1.25 (0.98)	0.84±0.37 (0.79)	1.36±0.55 (1.50)	***0.005*****
	4 months	2.20±1.13 (1.87)	1.49±0.51 (1.34)	1.37±0.50 (1.32)	1.60±0.44 (1.63)	*0.135*
	^{++}p	*0.325*	***0.023****	***0.001*****	***0.011****	
Nanohybrid	**Immediate**	1.19±0.97 (0.89)	0.91±0.31 (0.93)	0.75±0.46 (0.82)	0.63±0.46 (0.45)	*0.421*
	2 weeks	1.48±1.36 (1.07)	0.85±0.37 (0.80)	0.85±0.41 (0.98)	0.51±0.26 (0.56)	***0.039****
	4months	1.37±1.37 (1.15)	0.98±0.42 (1.10)	1.31±1.21 (1.05)	0.58±0.36 (0.60)	*0.218*
	^{++}p	*0.325*	*0.197*	*0.284*	*0.908*	
Fine particle hybrid	**Immediate**	0.78±0.25 (0.76)	0.79±0.18 (0.73)	0.82±0.15 (0.87)	0.79±0.34 (0.61)	*0.791*
	2weeks	0.86±0.36 (0.76)	0.77±0.17 (0.76)	0.91±0.29 (0.90)	0.78±0.55 (0.62)	*0.422*
	4 months	1.01±0.31 (0.96)	0.96±0.38 (0.88)	1.07±0.18 (1.11)	0.92±0.52 (0.69)	*0.290*
	^{++}p	***0.043****	*0.368*	***0.015****	*0.093*	

$^{+}$ *Kruskal Wallis Test*
$^{++}$ *Friedman Test*
** p<0.05*
*** p<0.01*

Table 3. *ΔE* values of restorative materials in bleaching agents tested

		Ormocer	**Nanohybrid**	**Fine particle hybrid**	
		Mean±SD (Median)	**Mean±SD (Median)**	**Mean±SD (Median)**	${}^{+}p$
Voco	**Immediate**	1.93±1.51 (1.48)	1.19±0.97 (0.89)	0.78±0.25 (0.76)	***0.049****
	2 weeks	2.33±1.24 (2.24)	1.48±1.36 (1.07)	0.86±0.36 (0.76)	***0.003*****
	4 months	2.20±1.13 (1.87)	1.37±1.37 (1.15)	1.01±0.31 (0.96)	***0.011****
	${}^{++}p$	*0.325*	*0.325*	***0.043****	
Viva	**Immediate**	1.01±0.81 (0.79)	0.91±0.31 (0.93)	0.79±0.18 (0.73)	*0.602*
	2 weeks	1.26±1.25 (0.98)	0.85±0.37 (0.80)	0.77±0.17 (0.76)	*0.717*
	4 months	1.49±0.51 (1.34)	0.98±0.42 (1.10)	0.96±0.38 (0.88)	***0.045****
	${}^{++}p$	***0.023****	*0.197*	*0.368*	
Opal	**Immediate**	0.58±0.34 (0.50)	0.75±0.46 (0.82)	0.82±0.15 (0.87)	*0.204*
	2 weeks	0.84±0.37 (0.79)	0.85±0.41 (0.98)	0.91±0.29 (0.90)	*0.841*
	4 months	1.37±0.50 (1.32)	1.31±1.21 (1.05)	1.07±0.18 (1.11)	*0.249*
	${}^{++}p$	***0.001*****	*0.284*	***0.015****	
Distilled water	**Immediate**	0.49±0.20 (0.46)	0.63±0.46 (0.45)	0.79±0.34 (0.61)	***0.037****
	2 weeks	1.36±0.55 (1.50)	0.51±0.26 (0.56)	0.78±0.55 (0.62)	***0.014****
	4 months	1.60±0.44 (1.63)	0.58±0.36 (0.60)	0.92±0.52 (0.69)	***0.002*****
	${}^{++}p$	***0.011****	*0.908*	*0.093*	

${}^{+}$ *Kruskal Wallis Test ** p<0.01* ${}^{++}$ *Friedman Test* p<0.05*

agents (*p*<.001). The immediate color changes of the control group were significantly lower than Voco *(p:0.002;* *p*<.01) and Viva *(p:0.040;* *p*<.05). The immediate color changes of Opalescence were significantly lower than Voco *(p:0.005;* *p*<.01). There was no statistically significant difference between the immediate ΔE values of bleaching agents (*p*<.05). There was statistically significant difference between the 2 weeks *ΔE* values of bleaching agents (*p*<.01). The 2 weeks *ΔE* values of Voco were significantly higher than the Viva *(p:0.021;* *p*<.05), Opalescence *(p:0.002;* *p*<.01) and control group *(p:0.021;* *p*<.05). There was no statistically significant difference between the 2 weeks *ΔE* values of bleaching agents (*p*>.05). There was no statistically significant difference between the 4 months *ΔE* values of bleaching agents (*p*>.05). There was no statistically significant difference between the immediate, 2 weeks and 4 months *ΔE* values of Voco (*p*>.05). There was statistically significant difference between the immediate, 2 weeks and 4 months *ΔE* values of Viva (*p*<.05). The 4 months *ΔE* values were significantly higher than the immediate *ΔE* values (*p:0.049;* *p*<.05). There were no significant differences for the other interval time periods tested (*p*>.05). There was statistically significant difference between the immediate, 2 weeks and 4 months *ΔE* values of Opalescence (*p*<.01). The 2 weeks (*p:0.012;* *p*<.05) and 4 months (*p:0.009;* *p*<.01) *ΔE* values were statistically significant than the immediate *ΔE* values also, 4 months (*p:0.012;* *p*<.05) *ΔE* values were statistically significant than the 2 weeks *ΔE* values. There was statistically significant difference between the immediate, 2 weeks and 4 months *ΔE* values of control group (*p*<.05). The 2 weeks (*p:0.025;* *p*<.05) and 4 months (*p:0.017;* *p*<.05) *ΔE* values were statistically significant than the immediate *ΔE* values also, 4 months (*p:0.036;* *p*<.05) *ΔE* values were statistically significant than the 2 weeks *ΔE* values.

In nanohybrid group, there were no statistically significant difference between the immediate ΔE values of bleaching agents (p>.05). There were statistically significant difference between the 2 weeks *ΔE* values of bleaching agents (*p*<.05). The 2 weeks *ΔE* values of control group were significantly lower than the Voco *(p:0.006;* *P*<.01), Viva *(p:0.046;* *p*<.05) and Opalescence *(p:0.048;* *p*<.05). There was no statistically significant difference between the 2 weeks *ΔE* values of bleaching agents (*p*>.05). There was no statistically significant difference between the 4 months *ΔE* values of bleaching agents (*p*>.05). There were no statistically significant difference between the 2 weeks and 4 months *ΔE* values of Voco, Viva, Opalescence and control group (*p*<.05).

For fine particle hybrid composite, only for the Voco and Opalescence group were statistically significant differences determined between the time intervals tested (*p*<.05). The mean *ΔE* values obtained after 4 months of immersion in distilled water were significantly higher than the mean *ΔE* values obtained after 2 weeks of bleaching procedure (*p*<.05). There were no significant differences for the other interval time periods tested.

Evaluation of the restorative materials in each bleaching agents and control group tested (Table 3) showed that Voco group demonstrated statistically significant color changes values after two weeks and 4 months of immersion in distilled water (*p*<.05). Voco-ormocer group is the most bleach group after 2 weeks of bleaching procedure. In Voco- ormocer group and either in Voco- nanohybrid group, there were any statistically significant difference between the mean *ΔE* values after 2 weeks and 4 months of immersion in distilled water (*p*>.05). There was statistically significant difference between the immediate, 2 weeks and 4 months *ΔE* values of fine particle hybrid resin group (*p*<.05). The 4 months *ΔE* values were statistically significant than the immediate (*p:0.017;* *p*<.05) and 2 weeks (*p:0.036;* *p*<.05) *ΔE* values. There was no statistically significant difference between the other time interval (*p*>.05).

For Viva bleaching agent, only at the 4 months of *ΔE* values were statistically significant (*p*<.05). *ΔE* values of ormocer group were statistically significant than the *ΔE* values of nanohybrid group (*p:0.046;* *p*<.05) and fine particle hybrid resin group (*p:0.036;* *p*<.05). There is no statististically significant difference between the *ΔE* values of nanohybrid group and fine particle hybrid resin group (*p*>.05).

For Opalescence bleaching agent, there was no statistically difference between the restorative materials for immediate, 2 weeks, 4 months ‘s of ΔE values ($p>.05$). There were statistically significant differences between the immediate, 2 weeks and 4 months ΔE values of ormocer groups ($p<.01$). The 2 weeks (*p:0.012;* $p<.05$) and 4 months (*p:0.009;* $p<.01$) ΔE values were statistically significant than the immediate ΔE values, also, 4 months (*p:0.012;* $p<.05$) ΔE values were statistically significant than the 2 weeks. There was no statistically significant difference between the immediate, 2 weeks and 4 months ΔE values for nanohybrid groups ($p>.05$). There was statistically significant difference between the immediate, 2 weeks and 4 months ΔE values for fine particle hybrid resin groups ($p>.05$). The 4 months (*p:0.018;* $p<.05$) ΔE values were statistically significant than the immediate ΔE values ($p>.05$). There was no statistically significant difference between the other time interval ($p>.05$).

For control group, there was statistically difference between the restorative materials for immediate ΔE values ($p<.05$). The immediate fine particle hybrid resin group’s ΔE values is higher than the ormocer’s (*p:0.009;* $p<.01$) and nanohybrid’s groups(*p:0.043;* $p<.05$). There was no statistically significant difference between the immediate ΔE values of ormocer and nanohybrid’s groups ($p>.05$). There were statistically significant difference between the 2 weeks ΔE values of restorative materials ($p<.05$). The ΔE values of ormocer’s groups were higher than the nanohybrid’s (*p:0.006;* $p<.01$) and fine particle hybrid resin (*p:0.045;* $p<.05$) groups. There is no statistically significant difference between the ormocer’s and fine particle hybrid resin’s groups ($p>.05$). There were statistically significant difference between the 4 months ΔE values of restorative materials ($p<.01$). The ΔE values of ormocer’s groups were higher than the nanohybrid’s (*p:0.02;* $p<.01$) and fine particle hybrid resin (*p:0.014;* $p<.05$) groups. There is no statistically significant difference between the ormocer’s and fine particle hybrid resin’s groups after 4 weeks of immersion in distilled water ($p>.05$). In ormocer groups, there was statistically significant difference between the immediate, 2 weeks and 4 months of ΔE values ($p<.05$). The 2 weeks (*p:0025;* $p<.05$) and 4 months (*p:0.017;* $p<.05$) ΔE values were statistically significant than the immediate ΔE values, also, There was no statistically significant difference between the other time interval ($p>.05$). The 4 months (*p:0.036;* $p<.05$) ΔE values were statistically significant than the 2 weeks ΔE values. There was no statistically significant difference between the immediate, 2 weeks and 4 months of ΔE values in nanohybrid’s groups and also in fine particle hybrid groups ($p>.05$).

Discussion

The null hypothesis was rejected in the presented study: there is a difference in color stability between the ormocer, nanohybrid and fine particle hybrid composite resin specimens bleached with different bleaching agents The ΔE of the ormocer and two composite resins, nanohybrid and microhybrid composite resin was continuing to increase during 4 months of follow-up periods or preserved their color, therefore the ΔE values of all restorative materials tested are clinically perceptible level ($\Delta E<3.7$). The most important result of this study is the incrementally rising value of ΔE. In the present study, as Johnston and Kao (17), the ΔE value=3.6 or>3.6 was accepted as clinically acceptable and the below of this value was considered as clinically unacceptable or clinically perceptible.

The ormocer group showed the highest color change among the tested materials. The most significant color change was seen at the Voco Perfect Bleaching (17% CP) groups (ΔE: 1.93) after 2 weeks of bleaching procedure. Comparison of the measurements made at the end of 2 weeks and 4 months of immersion in distilled water follow-up showed that the Voco Perfect Bleaching group specimens preserved their post-bleach color (ΔE 2 weeks: 2.33, ΔE 4 months 2.20). This means there is nearly no color changes between the 2 immersion times. The specimens bleached with VivaStyle (16%) and Opalescence (20%) bleaching gels continued to change color during 4 months of immersion period (VivaStyle: ΔE 2 weeks: 1.26, ΔE 4 months 1.49, Opalescence: ΔE 2 weeks: 0.84, ΔE 4 months 1.37), but the ΔE values of the specimens bleached with these 2 bleaching agents are always lower than the specimens bleached with Voco Perfect Bleaching agent. Further studies are needed to demonstrate the chemical variation between ormocer and bleaching agents. Control group of the restorative materials revealed that the ormocer group specimens changed also color during the follow-up period (ΔE immediate: 0.49, ΔE 2 weeks: 1.36, ΔE 4 months 1.60). But, the main factor is that ormocer-Voco group specimens ΔE values were nearly stable during follow-up period. With this information, it’s proper to report that bleached ormocer specimens preserved their color during 4 months follow-up period.

In nanohybrid group, slight color changes were occurred which showed no statistically significant difference after 2 weeks of bleaching procedure. The greatest color change was in the Voco Perfect Bleaching group (ΔE: 1.19). Delta *E* values of the specimens continued to increase at the end of the 2 weeks of immersion period in distilled water (ΔE 2 weeks: 1.48), but a slight decrease was seen at the end of 4 months of immersion period (ΔE 4 months 1.37). The ΔE value of the Opalescence bleaching group after 2 weeks of bleaching procedure was under 1 (ΔE: 0.75), but the specimens of this group continued to change color slightly during the immersion period in distilled water.

In fine particle microhybrid composite resin group, ΔE values of the bleached specimens were under 1 for all bleaching agents tested. The results are the same for the 2 weeks of immersion period, but at the end of the 4 months of immersion period, the ΔE value of the Voco Perfect Bleaching and Opalescence groups increased and the ΔE values reached to 1 (1.01,1.07 respectively).

Cullen et al (5) demonstrated first of all that bleaching agents containing carbamide peroxide created slight color changes with the microfilled composite resin restorative materials, and secondly observed that bleached specimens returned to prebleached color and the color differences were not apparent after a week. The second result of the present study is not in agreement with the results of Cullen et al (5) study. In principle, if a material is completely color stable, no color difference will be detected after its exposure to the testing environment and ΔE value will be 0 (14,15) Delta E value is obtained from the substraction of the final and initial color measurement ($\Delta E= [(L_F^*- L_I^*)^2 + (a_F^*- a_I^*)^2 + (b_F^*- a_I^*)^2]^{1/2)}$(16) In the present study, nanohybrid and fine particle hybrid composite resin tested created slight color changes after 2 weeks of bleaching procedure and it was consistent part with Cullen et al’s study (5). But, the results of 4 months of immersion in distilled water showed that the ΔE values of related composite materials continued to increase and reached to 1 which was clinically noticeable under optimal viewing conditions by trained observers (16) value for the colorimetric study. The results are always in clinically perceptible level. These are the only 4 months follow-up's results and further more long-term studies are needed to observe the color changing rate of tested materials which was the limitations of this study.

In other limitation of this study that it is an *in vitro* study. The result of this study could be changed in *in -vivo* condition due to the oral condition. The intraoral area is wet due to the saliva. In *in-vitro* test, the specimens were kept in a dry condition. But, the aim of this study is to determine the effectiveness of bleaching agents in different restorative material in long term follow-up periods. Therefore, furthers in vitro studies also could be done to compare the results of this study. The methodology of this study could increase the potentialfor color change of resins due to bleaching as compared to intraoral condition.

Haywoood et al (11) reported that the carbamide peroxide effectively lightened the color of teeth in 92 percent of 38 patients, with an average daily bleaching time of seven to eight hours after six week. Meireles et al (12) evaluated the whitening effect of 10 % and 16% carbamide peroxide on the teeth by visual shade matching and digital spectrophotometer. They were instructed the patients to use dispensed gel at night for a period of 2 h/day, during 3 weeks. They reported 4.3 and 4.6 ΔE values for 10% and 16% carbamide peroxide agents respectively after one week of bleaching treatment and 3.9 and 4.5 ΔE values for 6 months post bleaching respectively. The mean ΔE values of restorative materials reported in the presented study are always inferior to bleached teeth ΔE values. But, the comparison of these two values is impossible due to the difference in the methodology. Therefore, further long-term studies are needed to examine color changing effect of carbamide peroxide bleaching agents in teeth restored with composite resins especially with Ormocer.

Conclusion

In the light of the results of this study, the color of Ormocer was clinically perceptible after 2 weeks of bleaching procedure. The color of nanohybrid and fine particle hybrid composite resin materials was slightly affected by bleaching agents. Voco Perfect Bleach is the most effective bleaching agents and Viva Style is the least one after 2 weeks of bleaching procedure and after 2 weeks of immersion in distilled water. Post bleach color was stable for ormocer 4 months after the bleaching procedure.

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