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The Effect of a Current Home Bleaching Agent on the Color of Nine Tooth-Colored Restorative Materials Stained with Common Beverages: An In Vitro Study

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Abstract

Bleaching to whiten discolored teeth may affect the color of existing stained restorations. The purpose of this study was to determine the color changes that occurred in nine already stained restorative materials by common beverages after being subjected to a simulated home bleaching. Three glass ionomers (ceramic-reinforced, resin-modified, and conventional) and six composite resins (nanofilled, organically modified ceramic (ormocer), flowable ormocer, polyacid-modified, microhybrid, and flowable microhybrid) were used for this study. Disc-shaped specimens that were stained by coffee, tea or cola beverages were immersed in Opalescence home bleaching agent for 8 hours for 30 consecutive days. A spectrophotometer was used to determine the baseline CIE values (L0, a0, b0) of the stained specimens before bleaching and CIE values (L1, a1, b1) of the stained specimens after bleaching. Statistical analysis was conducted using paired samples T-test for comparing each two test groups at a P value of <.05. Results: The color changed significantly for all stained restorative materials tested after the application of home bleaching with some specimens showing spots of precipitated stain mainly glass ionomer specimens stained with coffee. Glass ionomers showed the highest color change followed by compomer, nanofilled and micro hybrid composites. Ormocers showed the least color change among all the materials tested. Tea stain was the most susceptible to the effect of bleaching in most restorative materials tested. Conclusion: Although home bleaching results in a lighter color change of stained restorations, remaining unesthetic stain precipitation spots may necessitate replacement of these restorations.

INTRODUCTION

Nowadays, the increased esthetic demands by most patients has resulted in an increase in the use of tooth-colored restorative materials as well as an increase in the usage of bleaching agents to whiten discolored teeth. Previous studies have shown that both composite resin and glass-ionomer restoratives are susceptible to staining by various media. [1,2,3] With the introduction of home bleaching technique [4] , the application of peroxide-based agents with carriers has increased substantially during the past decade. Carbamide Peroxide (CP) is a well-accepted agent for home bleaching. [5] Bleaching occurs when unstable free radicals interact chemically with organic pigment molecules contained in dental hard tissues, reducing them to smaller, less pigmented molecules. [6] In the past, a 10% concentration of carbamide peroxide was considered as the standard. [7,8] In an attempt to increase the efficiency of the bleaching process, higher concentrations were also used [9,10,11] . During the whitening process of discolored teeth, the application of bleaching agents with a carrier can influence the properties of existing restorations. [5] Materials with different chemical compositions such as glass ionomers, composites, compomers, or ormocers may respond differently to the same bleaching agent. Several studies revealed the effects of bleaching agents on the properties of existing restorations including their hardness [12,13] , roughness [14,15] , microleakage [16,17] , bonding to enamel [18] , and color stability [1,2,15,19,20,21,22] , but none has determined such effects on the color of existing stained restoratives that may become in contact with the bleaching agent during using home bleaching kits. Such effects may be disappointing or on the contrary, they may be satisfactory to the patient. This study aimed to determine the color changes [23,24] that occurred in nine restorative materials stained by coffee, tea, or cola including glass ionomers, composites, a polyacid-modified composite, and ormocers as a result of a simulated home bleaching.

MATERIALS AND METHODS

Nine esthetic restorative materials in shade A2 and one current home-bleaching system were selected for this study

(Table 1). A total of 135 disc-shaped specimens (1 mm thick, 10 mm in diameter) were used in this study, they were readily obtained from the author's previous study [3] where they were subjected to different staining beverages (coffee 45 specimens, tea 45 specimens and cola 45 specimens). All specimens were stored in distilled water at 37°C for 24 h before being subjected to bleaching. Home bleaching was simulated by placing specimens in Petri dishes filled with the bleaching agent for 8 hours for 30 consecutive days at 37°C to simulate night-time bleaching with a carrier [13,25,26]. Throughout the experiment, specimens were stored in a dark environment and the bleaching agent was replenished daily. During the test intervals, the specimens were rinsed with running tap water for 1 minute to remove the bleaching agent and placed in Petri dishes filled with distilled water for storage. At the end of the treatment period, the specimens were rinsed with running tap water and stored in distilled water for 24 hours. A spectrophotometer (Shimadzu UV-3101PC, Shimadzu Scientific Instruments) was used to determine the baseline CIE values (L0, a0, b0) of the stained specimens before bleaching and CIE values (L1, a1, b1) of the stained specimens after bleaching. [3,27,28] All measurements were repeated twice, and means for the L, a, and b values were calculated. The calculation of the color variation (ΔE) * between two color positions (after bleaching-base line) in three dimensional L*a*b*color space was as follows:

$$(\Delta E)^{*} = [(L1 - L0)^{2} + (a1 - a0)^{2} + (b1 - b0)^{2}]^{1/2}$$

The data were statistically analyzed using SPSS Version 12 (SPSS Inc). Variables were presented as means and standard deviations. Paired sample T-test was used to compare between (ΔE) the color change after staining and (ΔE) the color change after bleaching for each stain to determine significance of difference in color change after bleaching application. Statistical significance was considered to occur at a P value of < .05.

Figure 1

Table 1: Materials used in the study

Material	Category	Formulation	Manufacturer
AmalgomerCR (A CR)	Ceramic-reinforced GI type II	Powder: Na, Ca, Al fluorosilicates, shade pigments, ceramic fillers, freeze-dried polycarboxylic acid, tartaric acid (water-settable) Liquid: water	Advanced HealthCare
Photac-Fil (Ph F)	Resin modified GI type II	Powder: Na, Ca, Al fluorosilicates, shade pigments, vacuum-dried copolymer of acrylic and maleic acid Liquid: Bismethacrylates, HEMA, camphroquinone, water	3M ESPE
Ketac-Fil (Ke F)	Conventional GI type II	Powder: Na, Ca, Al fluorosilicates, shade pigments Liquid: polycarboxylic acid, tartaric acid, water	3M ESPE
Filtek Supreme (FS)	Nanofilled CR	21.5 wt% TEGDMA, UDMA; 78.5 wt% zirconiasilica filler particles	3M ESPE
Admira (Ad)	Ormocer-based CR	23wt% ormocer resin, BIS-GMA, UDMA, TEGDMA; 77wt% inorganic glass fillers	Voco
Admira Flow (Ad F)	Flowable ormocer-based CR	36 wt% ormocer resin, BIS-GMA, UDMA, TEGDMA; 64wt% inorganic glass Fillers	Voco
Freedom (Fr)	Polyacid-modified CR	23 wt% multi-functional methacrylic ester, 77 wt% inorganic filler	SDI
Tetric Ceram (TC)	Microhybrid CR	21 wt% BIS-GMA, UDMA, TEGDMA; 79 wt% Ba, Al, Yt, Ba-Al-Fl glass, spheroid mixed oxides, dispersed SiO2	Ivoclar Vivadent
Tetric Flow (TF)	Flowable microhybrid CR	32 wt% BIS-GMA, UDMA, TEGDMA, 68 wt% Ba, Al, Yt, Ba-Al-Fl glass, spheroid mixed oxides, dispersed SiO2	Ivoclar Vivadent
Bleaching system	Opalescence (home bleaching)	15% Carbamide Peroxide, 0.5% Potassium nitrate, 0.11% Floride ion	Ultradent

GI = glass ionomer; CR = composite resin; BIS-GMA = bisphenol A glycidyl methacrylate; HEMA = hydroxyethyl methacrylate; UDMA = urethane dimethacrylate; TEGDMA = triethyleneglycol dimethacrylate.

RESULTS

The color changes in the tested stained restorative materials after 30 days of bleaching using 15 % carbamide peroxide are presented in Table 2&3. The results revealed statistically significant changes in the color of all tested stained materials after bleaching with Opalescence home bleaching system. In general, the most detectable color changes occurred in glass ionomers accompanied by remaining stain spots in coffee-stained specimens. Compomer, hybrid and nanofilled composites showed lower color changes while ormocers were the least affected when treated with Opalescence home bleaching system. In comparison to coffee and cola stains, the color affection of tea-stained restoratives was generally higher. Figure 1&2 show the color change (ΔE) in two color positions (before bleaching & after bleaching) of the tested restorative materials and the percentage of color change respectively. Figure 3 shows eight stained specimens before and after bleaching application to represent the extremes of color change as well as remaining stain spots in coffee-stained glass ionomer.

Figure 2

Table 2: Mean ΔE values, standard deviations, and significance of differences for stained tested materials before and after bleaching application

	Mean ΔE (SD)								
	Coffee			Tea			Cola		
	Before bleaching	After bleaching	Sig.	Before bleaching	After bleaching	Sig	Before bleaching	After bleaching	Sig.
A CR	12.45 (0.19)	2.03 (0.139)	0.000	10.64 (0.01)	1.55 (0.265)	0.000	2.83 (0.01)	0.54 (0.05)	0.000
Ph F	28.29 (0.20)	7.56 (0.357)	0.000	20.60 (0.32)	3.71 (0.088)	0.000	13.26 (0.05)	3.41 (0.02)	0.000
Ke F	13.02 (0.13)	2.54 (0.349)	0.000	14.96 (0.01)	1.82 (0.058)	0.000	8.57 (0.02)	1.69 (0.05)	0.000
FS	21.54 (0.02)	7.27 (0.389)	0.000	15.00 (0.02)	3.71 (0.051)	0.000	1.93 (0.01)	0.69 (0.03)	0.000
Ad	27.08 (0.02)	22.64 (0.077)	0.000	19.68 (0.02)	11.0 (0.73)	0.000	7.89 (0.01)	4.42 (0.12)	0.000
Ad F	19.78 (0.02)	14.94 (0.03)	0.000	16.89 (0.02)	6.5 (0.048)	0.000	3.31 (0.03)	1.82 (0.06)	0.000
Fr	31.32 (0.01)	9.23 (0.058)	0.000	29.58 (0.01)	6.45 (0.109)	0.000	14.61 (0.01)	4.33 (0.17)	0.000
Te C	22.92 (0.01)	8.39 (0.30)	0.000	19.38 (0.01)	5.32 (0.46)	0.000	5.31 (0.01)	2.54 (0.35)	0.000
Te F	16.41 (0.01)	5.18 (0.32)	0.000	15.60 (0.03)	4.09 (0.27)	0.000	2.75 (0.02)	1.27 (0.01)	0.000

AmalgomerCR(A CR), Photac Fil(Ph F), Ketac Fil(Ke F), Filtek Supreme(FS) , Admira(Ad), Admira Flow(Ad F), Freedom(Fr), Tetric Ceram(Te C), Tetric Flow(Te F)

Figure 3

Table 3: Overall susceptibility of stained restorative materials to bleaching (percentage of color change) as obtained from the difference in color that occurred after bleaching in relation to the original color before bleaching

Stain	Least susceptible	Most susceptible	Order of susceptibility to change in color (% color change)
Coffee	Admira 16.4%	Amalgomer CR 83.7%	Admira (16.4) < Admira Flow (24.5) < Tetric Ceram (63.4) < Filtek Supreme (66.2) < Tetric Flow (68.4)< Freedom (70.5) < Photac-Fil (73.3) < Ketac-Fil (80.5) < Amalgomer CR (83.7).
Tea	Admira 44.1%	Ketac Fil 87.8%	Admira (44.1) < Admira Flow (61.5) < Tetric Ceram (72.5) < Tetric Flow (73.8) < Filtek Supreme (75.3) < Freedom (78.2) < Photac-Fil (82) < Amalgomer CR (85.4) < Ketac-Fil (87.8).
Cola	Admira 44%	Amalgomer CR 80.9	Admira (44) < Admira Flow (45) < Tetric Ceram (52.2) < Tetric Flow (53.8) < Filtek Supreme (64.2) < Freedom (70.4) < Photac-Fil (74.3) < Ketac-Fil (80.3) < Amalgomer CR (80.9).

Figure 4

Figure 1: Color change (mean ΔE) produced by stain and after bleaching on nine esthetic restorative materials

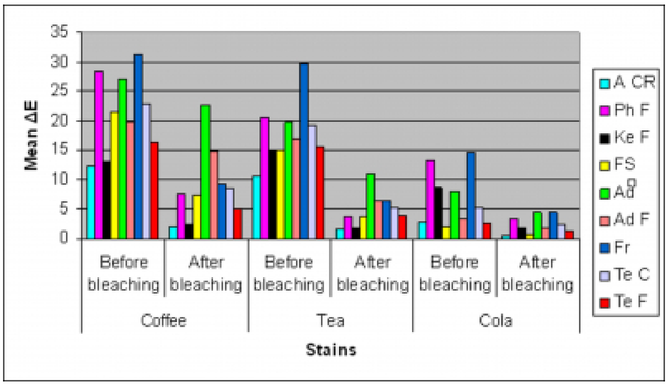


Figure 5

Figure 2: Percentage of color change produced by bleaching on nine stained esthetic restorative materials

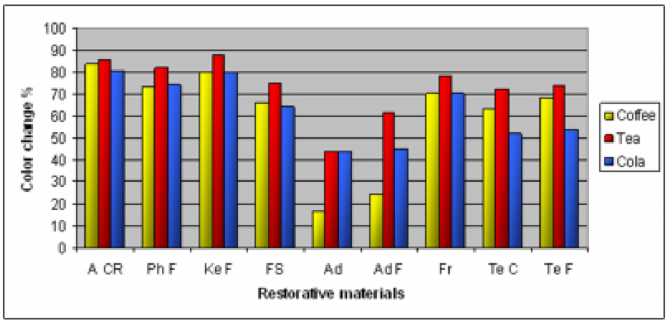
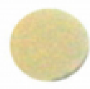


Figure 6

Figure 3: Eight stained specimens before and after bleaching application to represent the extremes of color change and reveal remaining unaesthetic stain spots.

Ketac Fil stained with coffee		
Amalgomer CR stained with coffee		
Ketac Fil stained with tea		
Amalgomer CR stained with cola		

DISCUSSION

Night-time bleaching with a carrier usually includes application of CP bleaching agent. On clinical application, CP breaks down into urea, ammonia, carbon dioxide, and Hydrogen Peroxide (HP), which is the active ingredient. These breakdown products may affect existing restorations. Glass ionomer restorative materials may undergo chemical softening due to erosion of matrix, wash off and release of metal cations from the surface. [29,30] Composite resin restorative materials may undergo alteration in their color as a result of oxidation of surface pigments and amine compound, which have also been indicated as responsible for color instability over time. [31] Changes in pH may also occur as a result of CP breakdown. Some restorative materials are pH sensitive for example, those which benefit from low oral pH to increase fluoride release, may be affected by the low pH of some peroxide-based bleaching systems. [32] The formerly mentioned causes are among the causes that may result in surface degradation associated with color changes of restorations. This study was concerned with the influence of a current home bleaching agent on the color behavior of a range of tooth-colored restorative materials that were subjected to staining by coffee, tea or cola. All stained restorative materials demonstrated a tendency to become lighter after treatment with the bleaching agent but in different amounts. The difference in the chemical composition among the materials tested as well as the type of beverage stain played important roles in the response to the bleaching agent. In general, glass ionomers showed the highest color change. This finding coincides with the results of another comparative study that revealed the higher affection of glass ionomers in vitro by bleaching agents than composites. [33] Obvious remaining stain spots were found in some coffee-stained specimens. This could be attributed to subsurface color alteration, implying a slight penetration of staining agents within the superficial layer (adsorption) that were away from the effect of the bleaching agent during bleaching procedure [34] . As regards to the different kinds of glass ionomer tested, conventional and ceramic-reinforced glass ionomer showed lighter color change when compared to resin-reinforced glass ionomer which to a great extent matched compomer in its response to bleaching. This may be attributed to the quite similar composition of both restorative materials which share the presence of both ionomeric part as well as resinous part of their composition. When bleached, they both showed lighter color change than all other tested composite groups. This may be ascribed to a limited polymerization reaction or the poly-acid content of the material. [33] If the polymerization reaction of the restorative materials result in low conversion rates, the bleaching material may react with unconverted C=C bonds of the monomer matrix system. In particular, traces of metals such as iron or copper, accelerating the decomposition to hydroxyl radicals, result in an enhanced efficacy of H_2O_2 [35] . In this study, nanofilled as well as micro hybrid composites showed slightly lower affection by the bleaching agent when compared to compomer. Differences in color change between different composite materials might be a result of different resin, filler content, initiation components and different degrees of conversion of resin matrix. [36,37] Both nanofilled and micro hybrid composites contain UDMA and TEGDMA whereas compomer contains methacrylic ester, which may be less resistant to the bleaching action. Both flowable microhybrid composite as well as flowable ormocer showed higher color affection when compared to the regularly-filled products. This can be attributed to the lower filler content of the formers. This finding is in agreement with the results of other studies which attributed the higher discoloration of certain composites to their lower filler concentration [24] and the lower resistance to oxidation to the higher resin content of the material [38] . Ormocers showed the least color change among all the materials tested. This coincides with the results obtained by other researchers who explained their findings on the basis of the resistance of inorganic glass fillers and/or the ormocer resin matrix to bleaching. [19]

LIMITATIONS OF THE STUDY AND CLINICAL SIGNIFICANCE

One of the limitations of this in vitro study is the lack of saliva. In clinical applications of bleaching products, even with tray-based systems, the concentration of active bleaching ingredients has been shown to be reduced due to the effect of saliva [39] . In the present study, the bleaching agent was left in contact with the restorative materials for 8h/day for 30 days without the dilution effect of saliva. . However, in the oral cavity, it would require a longer period of time to reach the obtained color changes. Another limitation of this study is the lack to evaluate teeth restored with tested restorative materials, stained by beverage stains and then exposed as one unit to bleaching procedure. This is indicated in further studies to gain information about the susceptibility of both discolored enamel and stained restorative materials to bleaching and hence the expected color matching or mismatching after bleaching application. Nevertheless, within the limits of the present study, the obtained results provide clinicians and patients with information about various susceptibilities of the tested stained restorative materials to color changes when subjected to home bleaching, which is valuable when taking into account patients' expectations from bleaching procedure. So, before performing home bleaching, it is important for the patient to know that the color of already stained restorations in his mouth may change, not only becoming lighter but in some cases may contain unesthetic stain spots depending on the type of restorative material as well as the type of staining food stuffs. This may affect the overall obtained results and may necessitate replacement of restorations.

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