Effect of bleaching on color change of composite after immersion in chlorhexidine and coffee

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Abstract

Background: Since the introduction of resin composites, the staining of resin-based materials by colored solutions such as coffee, tea, chlorhexidine (CHX), and other beverages has become a common concern.

Aim: The aim of this study was to evaluate the effect of home and office bleaching as a treatment for discoloration of composite after immersion in coffee or CHX.

Materials and Methods: A microhybrid composite (Z250), nanohybrid composite (Z550), and nanofill composite (ultimate, body shade) were selected. Forty disk shape specimens (8 mm diameter and 2 mm thickness) for each composite were prepared then divided into two groups according to staining solutions (25 g of coffee in 250 ml water, 20 min/day or 0.2% CHX, 1 min/day). Following 1 month staining, specimens were divided into two groups again. Half of the specimens was bleached with in-office bleaching agent (Opalescence Boost 40% hydrogen peroxide concentration) 3 times in one visit for 15 minutes and the others subjected to home bleaching agent (Opalescence 10% carbamide peroxide) 6h/day until 2 weeks both from Ultradent Products, Inc., South Jordan, UT, USA. Color of the specimens was measured with a spectrophotometer using CIELAB color space at baseline, after 1 month staining, and after ending the bleaching process.

Statistical Analysis: Analysis of variance was used to analyze the data (P < 0.05).

Results: Coffee and CHX provided significant color changes in all groups (P < 0.05). Z550 was the material more prone to discoloration in coffee in comparison with Filtek Ultimate (P = 0.003). After bleaching, materials showed significant reduction except stained Z550 by coffee in home bleaching groups. Both home and office bleaching provided significant color changes in all CHX groups (P < 0.05).

Conclusion: Coffee produced more color changes than CHX. The hydrogen peroxide has the same whitening effect in comparison with carbamide peroxide.

Keywords: Bleaching; carbamide peroxide; chlorhexidine; coffee; color; composite resin; extrinsic stain; hydrogen peroxide

INTRODUCTION

Increased esthetic demands by patients, improvements in formulation, and simplification of bonding procedures resulted in increasing clinical use of composite resins over the past few years. Nevertheless, composite resins are recommended for the restoration of all types of class of cavities in all teeth,[9] Since their introduction, the staining of resin-based materials by colored solutions such as coffee, tea, chlorhexidine (CHX), and other beverages has become a common concern. The staining caused by these beverages and solutions varies according to their

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composition and properties. Both science and technology of dental composite restorative materials have advanced to solve this problem. The resin-based materials that have been on the market have improved their physical properties due to new filling concepts and matrix changes. Unfortunately, discoloration is still a problem for dental resin composite restorations.

Composite surface discoloration by the deposition of extrinsic stains is currently treated by professional cleaning, polishing, bleaching, and in severe cases might be replaced. Up to date, a limited number of studies have reported the color change of tooth-colored materials due to bleaching treatments. The aim of this in vitro study was to evaluate the effect of home and office bleaching as a treatment for discoloration of composite after immersion in CHX and coffee solution.

**MATERIALS AND METHODS**

Three light-cured methacrylate-based resin composites, microhybrid composite (Filtek Z250), nanohybrid composite (Filtek Z550), and nanofill composite (Filtek Ultimate, body shade), were selected for this study. Detailed information of the materials is presented in Table 1. Specimens (8 mm diameter and 2 mm thickness, n = 40 for each composite resin) were prepared using a stainless steel mold. After applying the composite resin, a Mylar strip was placed and pressed with a glass slide to obtain a flat surface. The specimens were cured for 40 s using a halogen light-curing unit (Optilux 501 L.C; Kerr Corporation, Orange, CA, USA). The specimens were removed from the mold and assessed visually for void and structural defects. Defected specimens were excluded from the study. In the next step, the specimen surfaces were finished and polished using grit-600, 800, and 1000 silicon carbide paper, respectively. Then, baseline color was measured using a spectrophotometer (X-Rite, Grand Rapids, MI, USA).

Specimens were stored at 37°C in distilled water for 24 h. Thereafter, twenty specimens were stored in coffee (25 g in 250 ml of boiling water) 20 min/day, and the other twenty specimens were immersed in 0.2% CHX mouthwash solution 1 min/day until 1 month. All specimens remained in distilled water at 37°C in the incubator between the staining intervals. The color measurements were taken after 1 month staining using a spectrophotometer.

Following coloring intervals, stained specimens of each composite material were divided randomly into two groups. Ten specimens in each group were exposed to office bleaching agent. The treatment was performed according to manufacturer’s instruction only for one visit; during each visit, the application of the material was repeated three times. The office bleaching agent was Opalescence Boost 40% hydrogen peroxide concentration (Ultradent Products, Inc., South Jordan, UT, USA). Opalescence Boost 40% is a red gel supplied in two separate syringes, which were mixed and applied with a mixing tip for three cycles of 15 min each in one visit.

For the other ten specimens, the home bleaching technique, 10% carbamide peroxide (Opalescence 10%, Ultradent Products, USA) was placed on each sample surface, using a dispenser tip, forming a layer that was up to 1 mm thick. Bleaching agent was left in contact with each tooth sample for a period of 6 h daily until 2 weeks and was subsequently removed using cotton pellet and rinsing. During bleaching intervals, specimens were maintained in the incubator at 37°C. This procedure was repeated on a daily basis for a total of 2 weeks. After bleaching, color measurements were taken again.

The colorimeter displayed the different color parameters (L*, a*, and b*) according to the CIELAB color system, where L* describes the luminance reflectance, whereas a* and b* describe the red-green and yellow-blue color coordinates, respectively.

The change in color from the baseline was calculated after staining (ΔE₁) and after the bleaching sessions (ΔE₂). The change in color after the staining compared to the color after bleaching (ΔE₃) was also calculated. ΔE values were obtained using the Hunter’s equation.

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

All data were analyzed with the statistical software SPSS Version 23 (SPSS Inc., Chicago, IL, USA). The distributions

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**Table 1: Characteristics of the materials used in this study**

| Composite | Composition | Filler content | Type of composite | Manufacturer |
|-----------|-------------|----------------|-------------------|--------------|
| Filtek Z250 | Bis-GMA, UDMA, Bis-EMA, TEGDMA silica/zirconia (0.01-3.5 µ) | 75-85 wt% | Microhybrid | 3M ESPE Dental Products, St. Paul, MN, USA |
| Filtek Z550 | Bis-GMA, UDMA, Bis-EMA, TEGDMA, PEGDMA, nonagglomerated/ nonaggregated 20 nanometer silica/zirconia (3 µ or less) | 82 wt% | Nanohybrid | 3M ESPE Dental Products, St. Paul, MN, USA |
| Filtek Ultimate | Bis-GMA, UDMA, Bis-EMA, TEGDMA, PEGDMA nonagglomerated/nonaggregated 4-11 nanometer silica/zirconia, cluster filler (0.6-20 µ) | 78.5 wt% | Nanofill | Ultradent Products, Inc., South Jordan, UT, USA |

Bis-GMA: Bisphenol A glycidyl methacrylate, UDMA: Urethane dimethacrylate, Bis-EMA: Bisphenol-A-ethoxy methacrylate, TEGDMA: Triethylene glycol dimethacrylate, PEGDMA: Polyethylene glycol dimethacrylate
were assessed and found to be normal (Kolmogorov–Smirnov test). A three-way and two-way analysis of variance (ANOVA) test was applied to determine whether significant differences existed among the groups. Tukey’s test was applied as post hoc to evaluate pairwise comparisons. Significance was predetermined at \( P < 0.05 \).

**RESULTS**

Descriptive statistics (mean and standard deviation [SD]) of stained composite are summarized in Table 2. Two-way ANOVA showed that storage medium \( (P = 0.003) \) and material \( (P < 0.001) \) can affect \( \Delta E \). Coffee and CHX provided significant color changes in all groups \( (P < 0.05) \). Coffee resulted in greater discoloration in comparison with CHX. Tukey’s HSD (honestly significant difference) test showed that Filtek Z550 exhibited significantly higher values than Filtek Ultimate in coffee \( (P = 0.003) \). No significant differences were found when comparing other groups \( (P > 0.05) \).

Mean ± SD of \( \Delta E \) after composite bleaching is shown in Table 2. Three-way ANOVA showed that all factors (material, media, and bleaching agent) have influence on \( \Delta E \), \( P < 0.001, P < 0.001, \) and \( P = 0.004, \) respectively. After the bleaching procedure, materials tested showed significant reduction except stained Filtek Z550 by coffee in home bleaching groups \( (\Delta E_2 = 4.50 \pm 0.39) \). Coffee groups had significantly higher \( \Delta E \) values in comparison with CHX groups in all materials \( (P < 0.001) \). In CHX stained groups, there are no significant differences in \( \Delta E \) values after home and office bleaching.

Three-way ANOVA showed that none of the factors (material, media, and bleaching agent) have significant influence on \( \Delta E \), \( P = 0.149, P = 0.202, \) and \( P = 0.082, \) respectively. Both home and office bleaching provided significant color changes in all groups \( (P < 0.05) \), which is clinically acceptable \( (\Delta E_3 < 3.3) \).

**DISCUSSION**

Composite resin discoloration is a result of interactions between external colorants and the physicochemical properties of composite resin materials. The adsorption of external colorants onto the surface and the absorption of such into the resin matrices can both cause color changes and compromise the esthetic outcomes.\(^6\) While restorative materials have been tested in the past, new restorative composite resin materials require further investigation to solve the discoloration behavior as a problem.

The influence of background is quite a controversial topic; in fact, it has been claimed to have no, little or, great influence on color perception.\(^7,8\) Black and gray backgrounds better simulate the intraoral environment than white background.\(^9\) It was, therefore, decided to perform these measurements against natural gray background.

The color stability of a resin composite material is affected by many chemical factors of its resin components such as purity of the oligomers and monomers, concentration/ type of activators, initiators and inhibitors, oxidation of unreacted carbon–carbon double bonds, filler loading, and color of the inorganic pigments.\(^10,11\) Regarding the proportion of monomers in resin composition, high level of bisphenol A glycidyl methacrylate (bis-GMA, having hydrophilic hydroxide groups) present more water sorption and more susceptibility to staining than those having a high proportion of urethane dimethacrylate (UDMA, resin-containing aliphatic chains that are less hydrophilic).\(^12\)

In this regard, all composites demonstrated discoloration for the two staining solutions, especially for the coffee group. Furthermore, coffee seems to be responsible for the more staining because of acidic pH and more affinity to the polymer network.\(^13\)

For enhancing the healing after surgical procedures in the oral environment, the Food and Drug Administration (FDA) suggested a use of CHX (at 0.12% and 0.2% concentrations) recommended as oral rinses of 10–15 ml, for about 30 s, for a limited period of time (respectively, 1 month or 2 weeks).\(^14\) Hence, the discoloration by CHX as a side effect was investigated after 1 month. Several studies have investigated the effect of CHX and noted acceptable color changes \( (\Delta E < 3.3) \) as a side effect but with a slightly redder and darker appearance.\(^15,16\) Our results showed that all composites have been reached to \( \Delta E > 3.3 \) after immersion in CHX. The discrepancies could be attributed to the types of materials and duration of contact with the

| Composite     | Media | \( \Delta E_{1.2.3} \) (mean±SD) | \( \Delta E \) (mean±SD) | \( \Delta E \) (mean±SD) |
|---------------|-------|---------------------------------|--------------------------|--------------------------|
|               |       |                                 | Home                     | Office                    | Home                     | Office                    |
| Filtek Z250   | Coffee| 4.98±0.87                        | 2.67±0.52                | 2.48±0.23                | 2.47±0.44                | 2.99±0.52                |
|               | CHX   | 3.4±0.32                         | 1.67±0.25                | 1.78±0.21                | 2.44±0.39                | 2.48±0.40                |
| Filtek Z550   | Coffee| 5.04±0.38                        | 4.50±0.39                | 2.82±0.72                | 2.15±1.39                | 2.80±0.32                |
|               | CHX   | 4.03±0.59                        | 2.08±0.31                | 2.44±0.49                | 1.80±0.15                | 1.79±0.32                |
| Filtek Ultimate| Coffee| 3.50±0.42                        | 1.91±0.13                | 1.26±0.51                | 2.03±0.34                | 2.60±0.46                |
|              | CHX   | 4.10±0.65                        | 1.44±0.17                | 0.84±0.57                | 2.40±0.40                | 2.66±0.54                |

SD: Standard deviation, CHX: Chlorhexidine
Filtek Z550 showed the highest discoloration (ΔE) after immersion in coffee, significantly different from Z250 and Filtek Ultimate (P < 0.001). Greater staining in Filtek Z550 may be due to the wide distribution of particle sizes of this material. Materials with higher particle size, around 15 µm, tend to have lower performance in surface texture compared to materials with a mean particle size inferior to 1 µm[20,21] such as Filtek Ultimate.

Since their introduction, the use of bleaching agents has become increasingly popular for whitening stained teeth.[4,5] Bleaching effect of the bleaching agents on the same material might be different and could be attributed to their different contents. In our study, home bleaching systems were determined to be as effective as office bleaching system except in Z550 group. It may be due to its more color change in coffee and alterations in the surface. The color change of all composite resins bleached with hydrogen peroxide and carbamide peroxide solution was clinically detectable to the naked eye. The results of this study showed that the bleaching agents were produced clinically acceptable discoloration in removing the external staining for dental resin composites. The advantage of bleaching in comparison with polishing procedures for the elimination of stains is ease of availability and better access to the interproximal surface. Thus, patients should be advised that stained composite restorations may be treated by bleaching.

CONCLUSION

Coffee and CHX solutions can affect the color of composite resin materials used in this study. Extrinsic color change of nanofill, nanohybrid, and microhybrid composite resins bleached with 10% carbamide peroxide or 40% hydrogen peroxide bleaching agents results in the same outcome.

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Conflicts of interest
There are no conflicts of interest.

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