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Effect of Two Whitening Toothpastes on Composite Resin Restorations Discolored by 0.2% Chlorhexidine Mouthwash

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A B S T R A C T

Objectives: This study compared the effect of two whitening toothpastes on composite specimens discolored with 0.2% chlorhexidine (CHX).

Materials and Methods: Twenty-four composite specimens were fabricated from Charisma Diamond composite resin. The initial color of specimens was measured according to the CIE L*a*b* color system using a spectrophotometer. The specimens were immersed in 0.2% CHX twice a day for 1 minute each time, for 2 weeks. The color of specimens was measured again, and the specimens were assigned to three groups (n=8). The control group specimens were immersed in distilled water. The two test group specimens were brushed twice daily for 21 days with Oral B toothbrush and Signal White Now and Crest 3D White whitening toothpastes each time for 30 seconds. The color of specimens was measured again. Data were analyzed by one-way ANOVA and t-test.

Results: CHX increased the a, b, and L color parameters in all groups. There were no significant differences in ΔL (P=0.10), Δa (P=0.24), and Δb (P=0.07) among the study groups. The a, b, and L parameters decreased after brushing the specimens discolored with 0.2% CHX with the whitening toothpastes. There were significant differences in ΔL (P=0.03), Δa (P=0.02), and Δb (P=0.01) among the three study groups after using the whitening toothpastes. The highest ΔL, Δa, Δb, and ΔE values were recorded in Crest 3D White group, followed by Signal White Now group.

Conclusion: Crest 3D White whitening toothpaste had higher efficacy to resume the original color of composite specimens discolored with 0.2% CHX.

Key words: Chlorhexidine; Composite Resins; Toothpastes

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INTRODUCTION

Composite resins are currently the first choice among direct restorative materials [1]. Optimal esthetics is one of the reasons to select these restorative materials [2,3]. Color stability is a critical factor for restorative materials used for esthetic dental procedures [4]. The color stability of composite resins has a critical role in success of these restorative materials [5]. Composite resins are comprised of resin matrix, inorganic fillers, coupling agent, and initiators [6]. The resin matrix and inorganic fillers affect the surface smoothness and surface staining; while, resin type is more important in color stability of composite resins [4]. Composite resins are classified

according to various characteristics such as filler size, filler content, filler type, and mechanical properties [4]. In the recent years, nano-hybrid composite resins have been widely used. Nanotechnology is the production of structures in the range of 0.1 to 100 nanometers [4]. Nano-composite resins have esthetic properties required for anterior restorations and mechanical properties required for posterior restorations. However, composite resins cannot retain their color stability over long periods of time [7]. Poor color match is one of the primary reasons for replacement of composite restorations [4]. Composite resins undergo discoloration in the oral cavity due to external factors such as cigarette smoke, foodstuff, and drinks [7-9]. Chlorhexidine (CHX) is among the materials that cause significant discoloration in composite restorations. Today, use of mouthwashes has become popular to control caries and periodontal disease. CHX is a mouthwash with anti-plaque and chromo-genic activity [10]. The most important side effect of CHX is discoloration of teeth and restorative materials [11]. Some studies have reported discolorations caused by CHX [10-12], and some others have shown the optimal efficacy of whitening toothpastes in restoring the original color of discolored composite restorations [13].

Studies on CHX have shown that this mouthwash causes discoloration of composite resins, and the severity of discoloration depends on the type of composite resin [10,12]. Some studies have reported optimal efficacy of whitening toothpastes [13-15].

The present study aimed to evaluate the effect of two whitening toothpastes namely Crest 3D White and Signal White Now, on composite restorations discolored with 0.2% CHX mouthwash. The null hypothesis of the study was that application of Crest 3D White and Signal White Now whitening toothpastes would have no significant effect on composite resins discolored with 0.2% CHX mouthwash.

MATERIALS AND METHODS

This in vitro, experimental study was conducted at the Faculty of Dentistry, Kashan University of Medical Sciences, with the collaboration of the Faculty of Dentistry, Isfahan University of Medical Sciences, in 2019-2020. The study protocol was approved by the Ethics Committee of Kashan University of Medical Sciences (IR.KAUMS.MEDNT.REC.1399.051) with the research proposal code of 99056. Table 1 presents the characteristics of the materials used in the present study.

Table 1. Characteristics of the materials used in the present study

Material/Product	Manufacturer	Country	Ingredients
Crest 3D White toothpaste	Procter and GamBLe Co.	USA	Sodium fluoride, water, sorbitol, hydrated Silica, disodium pyrophosphate, sodium lauryl sulfate, cellulose gum, sodium hydroxide, sodium saccharin, carbomer, poly-ethylene, mica, titanium dioxide, blue 1 lake
Signal White Now toothpaste	Unilever Co.	France	Sodium fluoride, aqua, hydrogenated starch hydro-lysate, sodium lauryl sulfate, hydrated silica, PEG-32, aroma, calcium carbonate, cellulose gum, mica, sodium saccharin, PMV/MA copolymer, glycerin, trisodiom phosphate, sodium laureth sulfate, lecithin, limonene, Cl74160, Cl77891
Irsha 0.2% chlorhexidine mouthwash	Shafa Pharmaceutical Co.	Iran	Chlorhexidine digluconate, polysorbate 20, xylitol, glycerin, sorbitol, menthol, authorized cosmetics essential oil, PEG-40, cetylpyridinium chloride, Cl.16035, Cl.17200, citric acid, deionized water
Charisma Diamond	Heraeus – Kulzer Co.	Germany	TCD-urethane acrylate and UDMA (contains 64% filler by volume, 5nm-20µm) barium aluminum fluoride glass, highly discrete nanoparticles

Twenty-four specimens were fabricated from Charisma Diamond composite resin (BL shade; Heraeus Kulzer, Germany) using a mold measuring 5mm in diameter and 2mm in thickness.

The sample size was calculated to be 24 (n=8 in each group) considering the standard deviation of the mean color change to be 0.618, the mean color change of 0.3, 1.05 and 0.93 in the three groups, effect size of 0.6, and actual power of 0.86 using G Power software (3.1.9.4).

First, the mold was placed on a glass slab (Zolaltebshimi, Iran) and celluloid tape (TorVm, Russia), and composite resin was applied into the mold. A celluloid tape was placed over the mold, and a glass slab was placed on top of it. Then, a 5-kg load was placed over it to prevent void formation in the specimens and achieve a uniform thickness. Light-curing with a light-curing unit (DTE LUX-E; Woodpecker, China) was performed for 40 seconds with a light intensity of 8500 W/m^2. The samples were incubated at 37°C for 24 hours (Behdad, Iran) to ensure complete polymerization. Then, the upper and lateral surfaces were uniformly polished with aluminum oxide polishing discs (TorVm, Russia), followed by polishing with diamond polishing felt wheels (FGM, Brazil). The polishing procedure was carried out using a low-speed hand-piece for 30 seconds under dry conditions. The initial polishing was carried out to achieve a homogeneous surface and minimize discoloration caused by surface roughness. Then, the bottom surface of the specimens was coded. The specimens were rinsed and dried with a soft piece of cloth. Finally, to remove the fine particles resulting from the polishing procedure, the specimens were placed in an ultrasonic cleaner (Shenzhen Codyson Electrical Co., China) at a frequency of 35000 Hz for 90 seconds. The specimens that fractured upon removal from the mold, were contaminated during the fabrication process, or had voids after preparation were excluded.

A spectrophotometer (Shadepilot; DeguDent, Italy) and CIE L*a*b* color system were used to measure the initial color of specimens. The specimens were placed on a gray cardboard with a color code of #18 for color assessment. Condensation silicone impression material with putty consistency was used around the tip of the spectrophotometer. The hue, chroma, and value of all specimens were then measured.

The specimens were immersed in 0.2% CHX twice a day for 1 minute each time, for 2 weeks. The specimens did not contact each other or the container walls. After immersion in 0.2% CHX mouthwash, they were washed and stored in distilled water. After 2 weeks, spectrophotometry was repeated, and color parameters were measured again. The specimens were randomly assigned to three groups (A, B, and C) (n=8). Group A specimens were immersed in distilled water as the control group. Distilled water was replaced daily. The specimens in group B were brushed with Crest 3D White whitening toothpaste, and Signal White Now whitening toothpaste was used in group C. The specimens in groups B and C were brushed twice a day for 21 days with Oral B Vitality Cross Action toothbrush (Proctor and GamBLe, USA) and a pea size of each toothpaste (for each specimen) for 30 seconds each time with circular movement. The toothbrush was perpendicular to the surface of the specimens, and brushing was performed using an electric toothbrush with constant frequency (7600 strokes/minute). The specimens were placed on a hard surface and the toothbrush only contacted the surface of the specimens (without any force) to ensure uniform brushing. It is noteworthy that only one toothbrush was used during this process and after each time of brushing, the toothbrush and the specimens were rinsed with water. Then, the color parameters were measured again with a spectrophotometer in all three groups. The following formula was used for calculation of change in color parameters where ΔE represents the overall color change, ΔL represents the change in lightness, Δa indicates the change in greenness-redness, and Δb indicates the change in yellowness-blueness [16,17]:

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

The data were analyzed with one-way ANOVA, t-test, and Tukey's post hoc test using SPSS version 26.

Table 2. Color change after using 0.2% chlorhexidine mouthwash

Group	ΔL	Δa	Δb	ΔE
Distilled water	0.39±061	0.1±0.2	0.21±0.43	0.72±0.48
Crest 3D White	1.23±0.58	0.29±0.2	0.68±0.46	1.45±0.7
Signal White Now	1.08±1.05	0.24±0.26	0.90±0.79	1.64±1.01
The overall mean of the three groups	0.90±0.83	0.21±0.23	0.60±0.63	1.27±0.84

RESULTS

In the present study, 24 composite resin samples were evaluated in three groups (n=8). The mean ΔE after immersion in 0.2% CHX was 0.72 in the control group, and 1.45 and 1.64 in the Crest 3D White and Signal White Now whitening toothpaste groups, respectively (Table 2), with no significant difference in ΔE among the three groups according to ANOVA (P=0.06; Fig. 1). There were no significant differences in ΔL (P=0.10), Δa (P=0.24), and Δb (P=0.07) among the study groups either. After using the whitening toothpastes, the mean ΔE in the Crest 3D White and Signal White Now whitening toothpaste groups was 1.05 and 0.93, respectively; this value was 0.31 in the control group (Table 3). Based on ANOVA, there were significant differences among the study groups in ΔE (P=0.03; Fig. 1). In addition, there were significant differences in ΔL (P=0.03), Δa (P=0.02), and Δb (P=0.01) among the three study groups after using the whitening toothpastes. The Tukey's test showed significant differences in ΔL, Δa, Δb, and ΔE between the control group and the Crest 3D White whitening toothpaste group (P<0.05). There were significant differences in Δb between the control group and the two whitening toothpaste groups (P<0.05). The highest ΔL, Δa, Δb, and ΔE values were recorded in Crest 3D White whitening toothpaste, followed by the Signal White Now whitening toothpaste group, and the least values in the control group (Table 3).

DISCUSSION

The present study investigated the effect of two whitening toothpastes namely Crest 3D White and Signal White Now, on composite specimens discolored with 0.2% CHX mouthwash. The effects of Signal White Now and Crest 3D White bleaching toothpastes on color of composite restorations discolored by 0.2% CHX mouthwash were different. Thus, the null hypothesis of the study was rejected. When composite restorations are discolored, it is necessary to restore their original color. In the present study, a spectrophotometer with CIE Lab color system was used, which is the most accurate tool for color analysis [11]. In this system, color change is indicated by ΔE which is based on L, a and b values. L value refers to lightness and a and b values refer to chromaticity [10]. ΔE is divided into three categories: ΔE<1, which cannot be perceived by the human eye, 1< ΔE<3.3, which can be discerned only by specialists, and Δ>3.3, which can be discerned even by the laypeople [11]. After discoloration in the present study using 0.2% CHX, a ΔE of 1.27 was detected, which could clinically be discerned by specialists only. After using whitening toothpastes, a ΔE of 0.76 was obtained which is not discernible by the human eye. In the present study, 0.2% CHX mouthwash caused discoloration of composite specimens with no significant difference in ΔE among the three groups. Lack of a significant difference among the groups after using 0.2% CHX mouthwash indicates the homogeneity of the test conditions in the three study groups.

Table 3. Color change after using whitening toothpastes

Group	ΔL	Δa	Δb	ΔE
Distilled water	-0.21±0.36	0±0.13	-0.03±0.16	0.31±0.34
Crest 3D White	-0.88±0.71	-0.21±0.18	-0.48±0.33	1.05±0.77
Signal White Now	-0.79±0.38	-0.11±0.2	-0.41±0.27	0.93±0.43
Overall mean of the three groups	-0.63±0.57	-0.13±0.2	-0.30±0.32	0.76±0.62

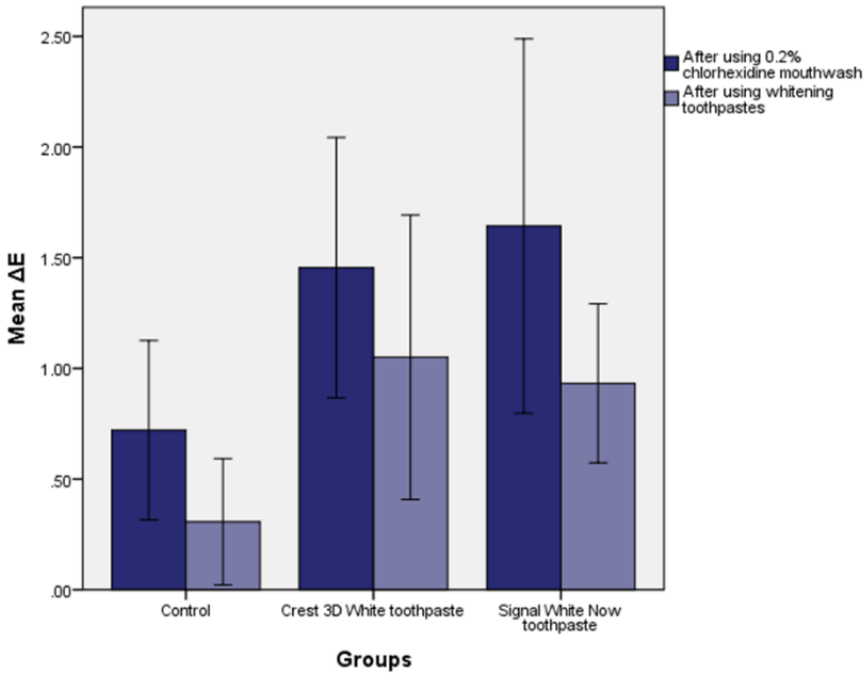

Fig. 1: Color change after the intervention

Different mechanisms have been proposed about discoloration caused by CHX, such as the precipitation of anionic dietary chromogens by the cationic disinfectants [10]. In the present study, similar to studies by Khosravi et al, [10] and Lee et al, [12] ΔE increased after using 0.2% CHX mouthwash. ΔE in these studies was in the range of 1<ΔE<3.3 and it could only be discerned by specialists. The similarity of the results with those of the abovementioned studies can be due to the similar immersion time in CHX (14 days) and the similar type of composite resin (nanocomposite) used. Whitening toothpastes have been evaluated in different studies. Aydin e al, [18] Reinharts et al, [16] Zhao et al, [13] and Manis et al. [14] showed that whitening toothpastes affected the discolored samples; however, ΔE was different in these studies, which might be attributed to differences in the composite resin types, resin chemical matrix [19], filler content [19,20], filler particle size [21], and polymerization percentage [22]. In the present study, after using the whitening toothpastes, the mean ΔE was not discernible by the human eye at all (ΔE<1); however, Reinharts et al, [16] and Manis et al. [14] reported more discoloration after using the whitening toothpastes; this difference can be due to the differences in the materials that cause discoloration. The primary discoloration in the present study was because of CHX but it was caused by coloring drinks in the aforementioned studies. The Munsell color system was the first system to show colors in a three-dimensional space [23]. According to this system [24], the specimens become more translucent, yellower, and redder after using 0.2% CHX mouthwash and become darker, greener, and bluer after using bleaching toothpastes.

The most visible color due to CHX discoloration was yellow and red in the present study. Also, a decrease in yellow and red color was observed by brushing with whitening toothpastes; however, the value also decreased after brushing with whitening toothpaste. It could be due to the increased surface roughness of the samples caused by the toothbrush. Lepri and Palma-Dibb [25] showed similar changes in value by brushing of composite specimens discolored by red wine. Also, Karadas [26] showed similar changes in value in the group brushed with

distilled water. However, Karadas [26] showed different changes in other groups. Thus, further studies are required to find the exact cause. The present study showed the superiority of Crest 3D White whitening toothpaste over Signal White Now whitening toothpaste. Evaluation of the ingredients of these two toothpastes reveals that the abrasive agents in Crest 3D White whitening toothpaste are silica hydrate and disodium pyrophosphate [26,27], while Signal White Now whitening toothpaste contains silica hydrate, calcium carbonate, and trisodium phosphate [28,29]. The abrasive agents in toothpastes might decrease lucency; however, the polishing agents in toothpastes, such as aluminum and silica, can prevent it [30]. Mika consists of aluminum and silica, and is found in both of these toothpastes. As a result, both of these toothpastes can preserve lucency. Therefore, the superiority of Crest 3D White toothpaste over Signal White Now toothpaste might be attributed to higher concentration of abrasive agents and Mika in Crest 3D White toothpaste. However, it is only a hypothesis, and further studies are necessary to confirm or reject it. Future studies on other types of composite resins and mouthwashes are required.

CONCLUSION

Within the limitations of this study, the results showed that Crest 3D White whitening toothpaste had higher efficacy to resume the original color of composite specimens discolored with 0.2% CHX mouthwash.

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CONFLICT OF INTEREST STATEMENT

None declared.

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