The impact of the diode laser 940 nm photoactivated bleaching on color change of different composite resin restorations

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Abstract

The study's main objective was to evaluate as well as compare the impact of diode laser 940 nm and conventional in-office bleaching technique on the color change of different composite resin restorations. A total of ninety composite resin discs (CRDs) were made from Filtek™ Bulk Fill, nanohybrid composite resin Filtek™ Z550 XT Universal Restorative, and flowable composite resin restoration Filtek™ Z350xt Flowable Composite. Group A: (30) CRD for Filtek™ Bulk Fill, group B: (30) CRD for Filtek™ Z550 XT Universal Restorative, and group C: (30) CRD for Filtek™ Z350xt Flowable Composite. A1, B1, and C1: (10 CRD in each group): Control group without bleaching. A2, B2, and C2: 10 CRD in each group bleached with Laser White20 without laser activation. A3, B3, and C3: 10 CRD in each group bleached with Laser White20 and activated by diode laser 940 nm. The color was evaluated using a dental spectrophotometer. One-way ANOVA was utilized for the comparison of the color stability of the CRD. $P < 0.05$ is regarded as statically significant. Both conventional and diode laser in-office vital tooth bleaching protocols affected the color stability of composite resin restorations. The result demonstrated that bleaching without laser activation produced color change (mean [8.30], standard deviation [SD] (1.95) P [< 0.001]), whereas the bleaching and activation by diode laser produced color change (mean [8.11], SD [1.99], P [< 0.001]). Both types of bleaching protocol affected composite resin restorations' color stability. In all tested materials, color changes after the bleaching protocol were clinically perceptible. The restorations following the bleaching procedure are required to be replaced by clinicians.

Key words: Color change, composite resin restorations, conventional bleaching, diode laser, laser-assisted bleaching

INTRODUCTION

Tooth bleaching became a popular procedure that was thought to be safe and effective. Contemporary bleaching methods in practice use a varying amount of hydrogen peroxide, ranging from 15% to 40%, the absence or presence of light, and the presence of rubber dam insulation.[1] As hydrogen peroxide decomposes, it releases free radicals and these have high reactivity characterization. They incorporate electron-rich pigments that are found in dental tissues. This results in the degradation of big-colored molecules into smaller and less-pigmented molecules.[2]

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Various sources of light, such as light-emitting diodes (LEDs), halogen lamps, plasma arc lights (PAC), and lasers, are employed to trigger the bleaching process. H_2O_2 is heated by a light source, which increases hydrogen peroxide breakdown into free radicals, which oxidize complicated organic compounds.[3] Diode lasers have a monochromatic characteristic that limits the danger of pulpal injury from overheating. 1.5-Watt output power diode laser has a photo thermal effect and can be used to activate the bleaching agent.[4]

Patients seeking tooth whitening can restore their teeth using various types of esthetic materials, including resin composites. After teeth whitening, the resin composite undergoes various optical changes, including color and translucency.[5] Resin composites, due to their organic matrix, are more likely to experience negative effects from tooth whitening treatments compared to other types of tooth-colored restorative materials.[6] Oxidative hydrolysis induced by peroxides at the C-C bonds of the polymer matrix leads to the degradation of the composite resin. Studies showed that various bleaching processes reduced the resin composite radiance and raised the tone to more yellowish and reddish colors.[7,8]

Composites are increasingly being used for both posterior and anterior restorations, allowing for a minimally invasive technique.[9] Nanohybrid composite restorations are widely preferred due to their superior filler distribution through the mix of nanoparticles and submicron particles.[10,11] The type, the concentration of fillers, the organic matrix of composite resin, as well as the bleaching agent's application time and concentration, all affect how well composite resin restorations react to bleaching agents.[12] The objective of the current research was to investigate the impact of 940-nm diode lasers and in-office bleaching on the color change of composite resin restorations. Previous research has examined the impact of diode lasers on the color of different types of composite resin restorations.

MATERIALS AND METHODS

Three restorative materials with A2 shade color were utilized in this investigation [Table 1]: A bulk-fill resin composite material Filtek™ Bulk Fill (3MESPE, Dental Product, St. Paul, MN, USA), nanohybrid composite resin Filtek™ Z550 XT Universal Restorative (3MESPE, Dental Product, St. Paul, MN, USA), and flowable composite resin restoration Filtek™ Z350xt Flowable Composite (3MESPE, Dental Product, St. Paul, MN, USA). The bleaching gel used was Laser White20 whitening (BIOLASE, Inc. 4 Cromwell Irvine, CA 92618 USA888-4 Biolase).

Preparation of samples

A total of 90 composite resin discs (CRDs) were constructed from metallic molds and divided into three main groups (n = 30/group) based on the types of composite resin restorations. The dimension of bulk-fill CRD was 10 mm × 4 mm and for nanohybrid flowable resin composites was 10 mm × 2 mm. A Mylar strip was inserted within the metal mold that was filled with test materials. A glass slab was then overlayed with a celluloid strip and a microscopic glass slide.[13] Following the placement of the resin composite material in the mold, the CRDs were light-cured from the top utilizing LED (Elipar S10, 3M ESPE, Germany) for 40 s (s). A radiometer was used to gauge the LED bulb's power before polymerization. Digital calipers were used to measure the thickness of each sample. Every sample was polished for 10 s at a slower speed with moderate pressure using fine and superfine paper discs fixed in a contra-angle handpiece (Sof-Lex™ Contouring and Polishing Discs Kit, 3M Company, St. Paul MN, USA). The samples were then submerged in distilled water for 24 h at 37°C to complete the polymerization process.[14]

The information in this text was obtained from manufacturer brochures. It lists various types of monomers, including TEGDMA (triethylene glycol dimethacrylate), Bis-GMA (bisphenol A-glycidyl methacrylate), Bis-EMA (bisphenol A ethoxylated dimethacrylate), AUDMA (a high-molecular weight aromatic dimethacrylate), PEGDMA (polyethylene glycol dimethacrylate), and DDDMA (1, 12-dodecanediol dimethacrylate). The acronym "AFM" stands for "addition − fragmentation monomers."

After completing the composite disc preparation, the discs were categorized into three groups according to the type of resin composite restorations and bleaching protocol [Figure 1]. Group A: 30 CRD for Filtek™ Bulk Fill, group B: 30 CRD for Filtek™ Z550 XT Universal Restorative, and group C: 30 CRD for Filtek™ Z350xt Flowable Composite. A1, B1, and C1: (10 CRD in each group): Control group without bleaching. A2, B2, and C2: 10 CRD in each group bleached with Laser White20 without laser activation. A3, B3, and C3: 10 CRD in each group bleached with Laser White20 and activated by diode laser 940 nm.

The bleaching procedure

Laser White20 gel was formulated by 25 times blending the base and activator syringe contents at room temperature to ensure homogeneity. A 1-mm layer of the Laser White20 gel was smeared and distributed across the surface of CRDs using the micro brush's tip. After that, the surface of CRDs was exposed to a diode laser (Epic X, Biolase, CA, USA) for 30 s, three times each at a distance of 1 mm, and power of 1.5W with a 1-min interval between irradiations. After 7 min, CRDs were washed for 30 s using distilled water.[15,16]

CRD in which the bleaching agent was not subjected to laser radiation was prepared as previously described. Surfaces were bleached for 20 min. CRDs were washed with distilled water and stored for 7 days in saline,

Table 1: Composite resins analyzed in this investigation

Composite	Manufacture	Type	Matrix composition	Filler particles	Filler amount
Filtek™ Bulk Fill	3M ESPE, St. Paul, MN, USA	Bulk-filled	AUDMA, AFM, DDDMA, UDMA	an aggregated zirconia/silica cluster (comprised of 20 nm silica and 4 to 11 nm zirconia particles) a ytterbium trifluoride filler consisting of agglomerate (100 nm)	76.5 wt. %
Filtek TM Z550 XT Universal Restorative	3M ESPE, St. Paul, MN, USA	Nanohybrid	BIS-GMA, UDMA, BIS-EMA, PEGDMA, TEGDMA	Combination of surface modified zirconia/silica with 0.1-10 μ particles and surface modified silica particles size of 20 nm	87 wt.%
Filtek TM 350 XT Flowable	3M ESPE, St. Paul, MN, USA	Flowable	Bis-GMA, TEGDMA, procrylate resin	Combination of 1-5μm yetterbium triflioride fillers; 20 and 75 nm non-agglomerated, non-aggregated silica fillers and 0.6-10 μm surface modified aggregated zirconia (4-11 nm)/silica -(20 nm) clusters	65 wt.%

Information gathered from manufacturer brochures. TEGDMA, triethylene glycol dimethacrylate; Bis-GMA, bisphenol A-glycidyl methacrylate; Bis-EMA, bisphenol A ethoxylated dimethacrylate; AUDMA, a high molecular weight aromatic dimethacrylate; PEGDMA, polyethylene glycol dimethacrylate; DDDMA, 1, 12-Dodecanediol dimethacrylate; AFM, addition-fragmentation monomers

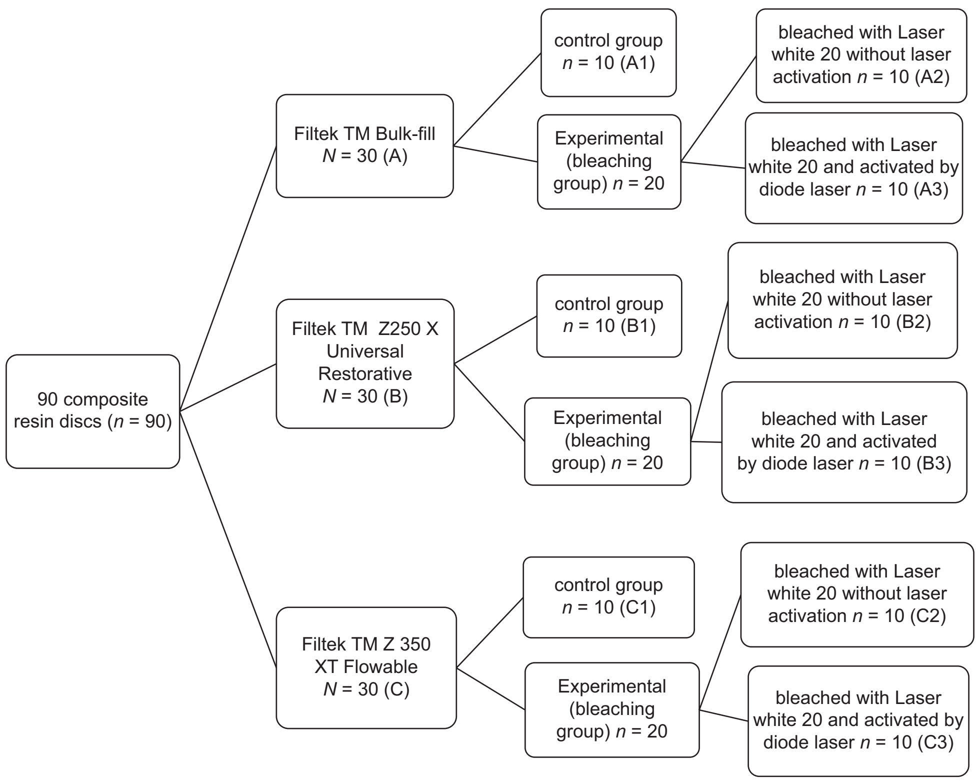

Figure 1: Distribution of composite resin discs

thereafter dried and evaluated colorimetrically with a spectrophotometer (Vita Easyshade, VITA Zahnfabrik, Germany). Color difference was determined using the CIELAB formula:[17]

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

L* parameter represents the degree of lightness, a* is indicate the redness/greenness, and b* indicates the yellowness/blueness.

SPSS version 21 (Statistical Package for Scientific Studies Inc., Chicago, IL, USA) was used to analyze the data.

RESULTS

As shown that both conventional and diode laser-assisted in-office vital tooth bleaching protocols affect the color stability of composite resin restorations. The result demonstrated that bleaching without laser activation produced color change with a mean (8.30), standard deviation (SD) (1.95), and P (< 0.001), whereas for the bleaching activated by the diode laser also produced color change with a mean (8.11), SD (1.99), and P (< 0.001). This indicated that there was a significant difference in color change value when compared with the control group in both bleaching protocols.

Table 2: Illustrates the impact of various bleaching techniques on the color stability of the filling materials discussed previously

Bleaching protocol	*n*	Mean	SD	SE	*P* (ANOVA)
Control group	30	2.658	0.351287288	0.064136	<0.001
Bleaching without laser activation	30	8.303667	1.959469463	0.357749	
Bleaching and activated by diode laser	30	8.113	1.995026834	0.36424	
Total	90	6.358222	3.084972485	0.325185	

n: Sample size, SD: Standard deviation, SE: Standard error

Table 3: Response of the composite resin restorations to different bleaching protocols

Filling materials	Subgroups	*n*	Mean	SD	SE	*P*
Filtek™ Bulk Fill composite resin	Control group	10	2.600	0.34322	0.10854	0.000
	Conventional bleaching	10	6.057	0.894962	0.283012	
	Diode laser bleaching	10	5.827	1.232766	0.389835	
Filtek™ Z550 XT universal restorative	Control group	10	2.6130	0.37316	0.11800	0.000
	Conventional bleaching	10	9.503	1.136975	0.359543	
	Diode laser bleaching	10	8.901	1.189402	0.376122	
Filtek™ Z350 XT flowable composite	Control group	10	2.7610	0.35044	0.11082	0.000
	Conventional bleaching	10	9.351	1.361163	0.430438	
	Diode laser bleaching	10	9.611	0.949087	0.300128	

SD: Standard deviation, SE: Standard error

Table 2 shows the effect of different bleaching protocol on the color stability of aforementioned filling materials.

Table 3 shows the response of the composite resin restorations to different bleaching protocols. The result demonstrated that all tested resin-based composite restorations had significant differences in comparison to control group P (< 0.001). Filtek™ Z550 XT Universal Restorative group and Filtek™ Z350xt Flowable RBCs show higher color change values in both bleaching protocols than Filtek™ Bulk Fill composite resin.

DISCUSSION

Vital tooth bleaching is a popular and effective esthetic dental procedure that is widely used due to its rapid results, safety, and popularity.[18] Although bleaching treatments seem noninvasive to patients, some authors have noted the negative effects of this therapy on dental restorations already in place in addition to oral and tooth tissues.[19]

This study evaluated the impact of tooth bleaching with a 940-nm diode laser compared to conventional bleaching on the stability of color of different resin-based composite restorations.[20] The result showed that both laser bleaching and conventional bleaching had an impact on the color stability of resin composite restorations. In agreement with previous research[21,22] bleaching that was activated by light using 40% hydrogen peroxide resulted in rougher resin-based composite surfaces. At high concentrations, the bleaching agents could cause the physical deterioration of resin-based composites.[21] Furthermore, lamps that radiate long wavelengths possess lower energy photons which results in high thermal that could generate unfavorable thermal effects. Nascimento *et al*. reported that the formation of hydroxyl radicals from hydrogen peroxide increases in photochemically initiated reactions utilizing light or lasers.[23] However, the diode laser has the same efficacy as conventional bleaching but in a shorter time.

According to the result of this study, following bleaching with 40% hydrogen peroxide, color differences among all tested composite resin restorations were above the threshold for visual perception. This seemed to be correlated with the amount, type of filler, and organic matrix structure differences.[24] The Filtek™ Z550 XT Universal Restorative group and Filtek™ Z350xt Flowable group exhibited similar color differences, being higher than those of the Filtek™ Bulk Fill composite resin restorations group. This could be explained by nanohybrid composites, as there was a significantly greater release of TEGDMA monomer, as TEGDMA has a smaller molecular weight than other monomers and it would be released from the samples immediately or theoretically, the release of hydroxyl radicals from bleaching gels might be increased by titanium dioxide, which could cause more severe structural alteration and deeper penetration into nanohybrid composites increasing the release of monomers.[25] Omrani *et al*. reported that using a laser in conjunction with a titanium dioxide-containing bleaching agent on nanohybrid composites might enhance monomer release following the bleaching procedure.[26] Theoretically, the interface between the matrix and filler is the most likely location for water buildup. The greater the surface area of nanohybrid-filled composites, the greater the collection of water between the filler and polymeric matrix. As a result of the absorbed water, the composite structure decomposes and the filer debonds from the polymeric matrix, resulting in additional monomer release.[27]

Filtek™ Z350xt Flowable types of resin-based composites group also exhibited color differences in the present study. These findings agree with previous studies. It is shown that bleach has a significant effect on the surface morphology of flowable composites. As the proportion of organic matrix increases, the quantity of filler reduces, leading to an increase in water absorption. This makes the composite resin more susceptible to discoloration.[28]

Filtek™ Bulk Fill composite resin restorations also exhibited significant color differences when compared with the control group, one of the main causes is the degree of conversion. Bulk-fill composites technique of application might cause fewer photons to reach the deeper regions of the composite resin which might result in a lesser degree of conversion. A lower degree of polymerization in deeper layers causes a higher uncured monomer and additive elution. Furthermore, this corrosive activity might promote surface roughness and deterioration and increases water sorption in resin-based composites.[29]

CONCLUSION

Within the limitations of the current study, diode laser-assisted bleaching treatment with 40% hydrogen peroxide caused unacceptable color changes in the tested resin-based composite restorations.

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Conflicts of interest
There are no conflicts of interest.

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