

Effect of Tea on Color Change of Silorane and Methacrylate based Composite Resins

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Abstract

Background and Aim: At present, stainability and color instability of tooth-colored restorations following the consumption of colored beverages are among the problems commonly encountered in restorative dentistry. Filtek P90 composite resin comprising of Oxirane and Siloxanefunctional moieties was recently introduced aiming at reducing the polymerization shrinkage. The aim of this study was to evaluate the effect of tea on color change of P90 and Z250 composite resins using spectrophotometry.

Materials and Methods: For this experimental study, 20 composite discs were fabricated in metal molds from Z250 and P90 composite resins and light cured using LED light-curing unit. Specimens were stored in distilled water at 37°C for 24 hours to allow completion of polymerization. Color of specimens was then measured at baseline and after 5 days of storage in water and tea solution using spectrophotometer. Data were analyzed using independent sample t-test and two-way ANOVA.

Results: The color change of P90 and Z250 composites after storage in distilled water was not significant in comparison to their baseline color ($P > 0.05$). However, both composite resins showed a significant change in color after storage in tea solution ($P < 0.05$). Stainability of Z250 composite in tea was significantly greater than that of P90; but in distilled water P90 showed greater color change than Z250.

Conclusion: Within the limitations of this study, Z250 composite demonstrated significantly greater color change in comparison to P90 after immersion in tea solution.

Key Words: Low-shrinkage composite resin, color stability, stainability, spectrophotometer

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Introduction

Composite restorations have become increasingly popular during the recent years due to the higher demand of patients for esthetic restorations and improved characteristics of composites along with their greater bond strength [1]. At present, stainability and color instability of tooth-colored restorations following the consumption of colored beverages are among the problems commonly encountered in restorative dentistry [2]. An important goal of restorative dentistry is to restore the natural color of teeth and replace the discolored composite

restorations [3]. Color change of composite restorations is influenced by internal and external factors. Intrinsic discoloration is due to changes in resin matrix and at the matrix-filler interface that occur over time during the process of aging. Extrinsic color change is attributed to the bonding or penetration of a coloring agent such as tea, coffee, colored food or cigarette smoke to the restoration surface [4]. Structure of composites and their filler characteristics can affect external staining [5]. Recently, new composites such as P90 comprising of Siloxane (hydrophobing agent) and Oxirane

(shrinkage reducing agent) functional moieties were introduced to the market.

FiltekP90 resin is comprised of ring-opening monomers. During the polymerization, monomers connect through opening, flattening and extending toward one another. This phenomenon significantly reduces the polymerization shrinkage compared to that of methacrylate-based composites with linear monomers. P90 has a higher hydrophobicity compared to conventional composite resins such as Z250. Thus, it is expected to have lower stainability [6].

A large number of studies have evaluated and compared the mechanical and optical properties of P90 resin with conventional composite resins [7-8]. Furus et al. assessed and compared the color stability of P90 to that of dimethacrylate composites after aging using spectrophotometer. They found that P90 had the greatest color stability after aging [2].

This experimental study evaluated the effect of tea on color change of Filtek Silorane (3M ESPE, USA 9999) and Z250 (3M ESPE, USA) composite resins using a spectrophotometer (Sp64rite, USA).

Materials and Methods

This in-vitro experimental study was conducted on P90 and Z250 composite resins. The characteristics and composition of these materials are presented in Table 1. Ten specimens measuring 10 mm in diameter and 2 mm in height were fabricated with A3 shade of the mentioned composites. The required amount of the mentioned composites were placed into the molds and pressed by placement of one mm thick glass slabs beneath and above the metal mold. By doing so, air entrapment, voids and surface irregularities were eliminated. Samples were cured for 120 s from each side using the overlapping technique and LED light-curing unit (Star Light Pro, Italy) with 600 mW/cm² intensity (intensity of the device was assessed with a radiometer after fabrication of each specimen). Specimen surfaces (upper, lower and lateral surfaces) were polished by the use of low-speed hand piece and Soflex polishing discs (3M ESPE) starting from coarse to fine with 4000 grit to achieve smooth surfaces and eliminate any possible contamination and oxygen-inhibited layer. Specimens were then stored in distilled water at 37°C for 24 hours to

allow completion of polymerization. Primary color assessment of specimens was done using spectrophotometer. In the next step, each group was randomly divided into 2 subgroups of 5 for storage in water and tea solution for 5 days. To prepare the tea solution, a tea bag (Lipton, England) was placed in 200 ml boiling water for 2 minutes. After removal of the tea bag, the solution volume was reached to 200 ml again. Distilled water at 55° C was used for the control subgroups. Samples along with the respective solutions were kept in closed containers to prevent evaporation of solutions and stored for 5 days in an incubator at 37°C [5]. Solutions were refreshed every 24 hours. Specimens were removed from the solutions, placed in distilled water container and were shaken 10 times, rinsed with distilled water for 5 seconds and cleaned with a soft toothbrush to remove any debris or contamination. All samples underwent color assessment with Sp64rite (USA) spectrophotometer. Color change of specimens (ΔE) was calculated according to the following formula:

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

Two-way ANOVA was applied to assess and compare the results of two composite resins and independent sample t-test was used to evaluate data before and after color change in each group ($P < 0.05$).

Results

Two-way ANOVA and independent sample t-test showed that the P90 and Z250 composites did not undergo significant color change after storage in distilled water ($P > 0.05$). P90 showed higher color change than Z250 in distilled water ($P = 0.03$).

P90 demonstrated a significant change in color after immersion in tea solution compared to its baseline color ($P < 0.05$). Also, Z250 composite resin underwent a significant change in color due to storage in tea solution ($P < 0.05$) (Table 2). Color change of Z250 in tea solution was significantly greater than that of P90 ($P = 0.04$) (Table 3).

Discussion

Color stability is a pivotal factor for long-term esthetics of tooth-colored restorations. Discoloration of composite restorations violates their main indication for use. Composite restorations are mainly applied for their color particularly in the

Table 1: Type and composition of understudy composite resins

Type of composite	Manufacturing company	Resin	Filler	Weight percent	Volume percent	Filler size
P90	3MESPE,st. Paul,MN,USA	Silorane	Quartz, Yttrium fluoride	76%	55%	0/04-1/7
Z250	3MESPE,st. Paul,MN,USA	Bis-GMA,Bis-EMA,UDMA,TEGDMA	Zirconia, silica	60%	60%	0/01-3/5

Table 2: Mean and SD value of color change (ΔE) in two composite resins due to storage in distilled water and tea solution

Composite	Solution	ΔE in tea compared to baseline	P.V	ΔE in water compared to baseline	P.V
Silorane		6/98 \pm 0/94	P<0/05	1/63 \pm 0/21	P<0/05
Z250		10/39 \pm 0/83	P<0/05	0/81 \pm 0/77	P<0/05

Table 3: Mean and SD value of color change (ΔE) in two composite resins due to storage in distilled water and tea solution

Composite	Solution	ΔE in tea compared to baseline	P.V	ΔE in water compared to baseline	P.V
Silorane		6/98 \pm 0/94		1/63 \pm 0/21	
Z250		10/39 \pm 0/83	0/04	0/81 \pm 0/77	0/03

anterior region and thus, maintaining their esthetics and optimal color determines their longevity and survival [5]. Based on the obtained study results, color change of both P90 and Z250 composites due to immersion in tea solution was significant and clinically unacceptable ($\Delta E > 3.3$). However, color change of P90 was significantly less than that of Z250. Color change of the two composites in distilled water (control) was clinically insignificant but P90 showed greater color change in distilled water.

Color assessment varies from person to person and even in one individual at different time points. In this study, in order to eliminate the subjective errors, color assessment was done using spectrophotometer (Sp64rite, USA). The accuracy of this device has been confirmed in various studies [4-5]. Duration of storage in tea solution was 5 days and equal for all samples. Selection of 5 days time period was due to the fact that if a person averagely drinks 4 cups of tea every day with the mean duration of drinking a cup of tea being one minute, every 24-hour immersion in tea solution would correspond to one year consumption of tea. Considering the fact that the mean survival of composite storage in tea solution would correspond to 5 years

restorations is approximately 5 years, 5 days of tea consumption. In order to simulate the in-vivo conditions (oral cavity environment), 37°C temperature was selected [9]. Since surface roughness can affect the stainability and optical properties of restorations, all samples were polished with course to fine Soflex (3M ESPE) polishing discs to match the specimens and then final color reading was carried out [10].

Color change of composite restorations over time is a multi-factorial process. Intrinsic factors cause chemical changes in resin matrix and at the resin-filler interface. Extrinsic color change is due to the absorption and adsorption of extrinsic coloring agents. It is also influenced by patient's nutrition and oral hygiene [4, 10]. However, stainability of composite resins depends on their surface characteristics, amount and size of filler particles and physical and chemical characteristics of resin matrix such as water sorption rate and their hydrophilic properties [11,12]. In this study, tea, a popular drink in Iran, was selected for assessment of stainability of tooth-colored restorations. Usually, stains of tea and coffee can cause superficial discoloration of composite restorations due to adsorption and absorption mechanisms. In case of adsorp

tion, the discoloration is corrected by tooth brushing to some extent. Tea stains mostly result in surface discoloration of composite restorations through the process of adsorption [13, 14]. Filtek P90 resin is composed of Siloxane and Oxirane functional moieties. Oxirane reduces polymerization shrinkage and causes greater stability against physical and chemical forces. Siloxane has greater hydrophobicity than methyl methacrylate-based composites [6]. According to previous studies, hydrophilic materials have high water sorption and undergo greater color change due to coloring agents in comparison to hydrophobic substances [5]. Therefore, P90 resin is expected to absorb less stain and undergo less color change. Increased hydrophobicity of Silorane also reduces the adhesion of streptococci that per se, can decrease the risk of secondary caries and increase the longevity and survival of restorations [15].

Although the color change of the two composite resins in distilled water was not clinically significant, P90 suffered a greater change in color. Our study results were in accord with those of Schneider et al, who compared the degradation resistance of P90, pure-ormocer and dimethacrylate resin-based composite resins. Percentage of hardness decrease, color stability, water sorption and solubility were assessed in their study as well. Silorane-based composites demonstrated lower hardness decrease, water sorption and solubility than other composites. But, their color stability was lower after 7 days of immersion in distilled aqueous media. It should be noted that duration of storage in water in their study was 48 hours longer than in our study and more distinct color change in their study may be due to this factor [16].

The covalent bond between glass fillers and different resin compounds can significantly affect the strength and physical properties of composite resins [9]. Composites with larger filler particles are more susceptible to color change due to immersion in water compared to those with smaller filler particles [5]. Pires-de-Souza et al. reported lower color stability in Silorane-based composites compared to methyl methacrylate-based ones. In micrograph assessments, they noticed that the quartz particles were separated from the P90 resin matrix due to aging, creating an uncertainty regarding the bond strength between quartz fillers and modified Silane

in P90 composite [12]. Color stability also has a direct correlation with degree of polymerization [17]. Nemati et al. evaluated the degree of polymerization of P90 and Z250 composite resins after curing and noticed a lower polymerization degree in P90 [18]. However, in Palin's study, polymerization of P90 composites continued for 24 hours after the initiation of polymerization and was increasing in comparison to Z250 and Z100 composites. This phenomenon depends on the rate of ring-opening polymerization and presence of active cations after 24-48 hours [19]. Thus, we may conclude that greater color change of P90 in water compared to Z250 is due to higher water sorption particularly in the first 24 hours and loss of the covalent bond between filler and matrix. On the other hand, polymerization continues in P90 and its hydrophobic property reduces the extrinsic color change. Duration of water immersion for the control group in this study was not sufficient for the assessment of color change due to aging and the obtained color change was less than the clinically perceptible level ($\Delta E < 3.3$). However, P90 showed greater color change in distilled aqueous media than Z250 and this finding necessitates further investigations based on standard methods. Furthermore, the effect of various media on composite color change should be evaluated.

Conclusion

1. P90 and Z250 composite resins underwent color change after immersion in tea solution
2. The amount of color change in the two composites following immersion in tea solution was not clinically acceptable.
3. P90 composite had lower stainability than Z250.
4. P90 and Z250 composites did not undergo significant color change after immersion in water but P90, in comparison to Z250, showed greater color change.

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