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Color stability of aesthetic composite restoration using LED and halogen light cure

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Abstract
Aim: To determine color stability of two different composites resins with same shade using LED and halogen light cure upon exposure to different types of staining media.
Methods: The colors of all specimens before and after storage in the solutions were measured by a spectrophotometer based on CIE Lab system, and the color differences thereby calculated. Data were analyzed by two-way analysis of variance (ANOVA) and Scheffe's post hoc test.
Results: Overall, the highest ΔE was observed with Z350 material, halogen light cure, mustard staining media, and at 30 days time. There was statistically significant mean difference (ΔE) between all the staining media except between ketchup and distilled water. Similarly, a statistically significant mean difference (ΔE) was found between all time periods except between one day and baseline.
Conclusion: It can be concluded that all staining media used in this study affected the color stability of the tested materials with time. Further studies with longer period of aging are warranted by the findings of this study.

Keywords: Color stability, light-curing mode, composite resin

Introduction
Aesthetic demand nowadays becomes major concern for the patient and discoloration of anterior composite is a main reason for replacement of restoration. Consumption of staining drinks, beverages, and food can influence discoloration of these restorations. Many researchers have been reported that the effect of extrinsic stain such as tea and coffee in color stability of composite restoration. Researcher defined extrinsic stain as the stain from exogenous source or through the accumulation of plaque into the composite's surface [1].
The resin matrix of composite has an important role in staining susceptibility [2]. It has been reported that the structure of the composite and the patient's habit have direct effect on susceptibility to extrinsic staining [3]. Tooth colored composite resin restoration have been classified according to filler type distribution and the particle size [4]. Recently, by minimizing the filler size the newly introduced nano-composite with approximately 40-50 nm can provide excellent aesthetics and polished surface [1].
There are four types of light cure: quartz-tungsten halogen (QTH), light-emitting diode (LED), plasma arc (PAC), and argon-ion laser. The QTH and LED are the most common light curing units used in dentistry [5]. QTH has broad emission spectrum but low efficiency in converting electronic energy, light filters are required to reduce heat, and has short lifespan. In contrast, the LED has long lifespan, produce less heat, don't require filters to produce blue light, and more efficient in converting electronic energy [6].
Color change in light cured composite resin are related to extrinsic factors, surface roughness, contact time with staining solutions, and type of composite resin used [7]. Generally, two system used to express the color in material tested: Munsell color system and CIELAB. The CIELAB system is recommend by American dental association (ADA) [8]. A study used two different solutions (black tea and cola) to compare their effect on three different types of composite and compomer and found that the compomer showed unacceptable color changed with both the solutions [1].
The effect of light cure (QTH and LED) and staining solutions (tea and coffee) on two types of composite found that the hybrid composite is more color stable than the nano-hybrid [5].

Another study tested two types of composite in different types of solutions (tea, cola, and red wine) and found that the material which did not contain TEGDAM is more color stable [2]. Furthermore, a study evaluated the color stability of two different types of composite (nano-hybrid and micro-hybrid) in different color solutions (coffee, tea, and cola) and found that the micro-hybrid has less color change than the nano-hybrid [7].

A study tested three types of composite in different types of solutions (artificial saliva, granule lemon juice, coffee, cola, sour cherry juice, fresh carrot juice, and red wine) and found nano-composite is the least discolored material than the others and red wine caused the most color change in all material [8]. However, some staining solutions such as ketchup, mustard, Arabic coffee has been tested in a very limited study. The aim of study was to determine color stability of two different composites resins with same shade using LED and halogen light cure upon exposure to three different types of staining solutions (ketchup, mustard, and Arabic coffee).

Materials and methods

Thirty two specimens were prepared from two different types of composite nano-hybrid (Filtek Z350 XT and micro-hybrid (Filtek Z250) shade A2. The specimens were 10mm in diameter and 2mm in thickness and prepared in brown bronze type of metal and covered with celluloid matrix and glass slide. The matrix was placed onto the composite each side in order to increase surface smoothness and facilitate polishing subsequently. Each type of composite was divided randomly into two groups according to the curing unit used. Group 1 specimens (n=8) were cured with QTH with light intensity of 470mw/cm^2, Group -2 specimens (n=8) were cured with LED with light intensity of 850mw/cm^2.

Table 1: Contents of composite materials used in this study

Product	Composite resin type	Composition	Particles	Manufacturer
Filtek Z250	Microhybrid	BIS-GAM UDMA BIS-EMA	Zirconia/silica 0.01 to 3.5μm	3M ESPE Dental products St. Paull, MN, USA
Filtek Z350	Nanohybrid	BIS-GMA UDMA TEGDMA PEGDMA BIS-EMA	20 nm silica and 4 to 11 nm zirconia	3M ESPE Dental products St. Paull, MN, USA

Table 1 lists the other details of the resin composites used in this study. The curing time was according to the manufacturer. The distance between the light and specimen was standardized by use of 1mm glass slide. The 8 specimens of each group were further divided into 4 sub-groups that were submerged into distilled water as control group, 25ml of ketchup, 25ml of mustard, Arabic coffee. The specimens were stored in distilled water for 24 hours at 37 °C before baseline color evaluation. After matrix removal the specimen were stored in light-proof dark plastic receptacles, then mark was made in the specimen to ensure that color reading would be done always at the same spot.

The distilled water in control group was changed daily for 30 days and saved. The specimen immersion was carried out for half an hour, once a day at room temperature. After each immersion process the specimen were washed with distilled water and stored in distilled water at room temperature during the 30 days cycle. The measurements were made at day 1, day 7 and day 30. Before each evaluation the specimen were washed with distilled water, gently brushed, and blot dried with absorbent paper. The color of the specimens was analyzed with spectrophotometer and color was evaluated according to the color system CIE Lab (Commission Internationale d'Eclairage L*, a*, b*).

Each specimen was measured twice and the ΔE* value was calculated by the following equation: $\Delta E^* = [L_1^* - L_0^*)^2 + (a_1^* - a_0^*)^2 + (b_1^* - b_0^*)^2]^{1/2}$. The data was analysed using IBM-SPSS, Version 22 for Windows. Descriptive analysis was used to present an overview of the findings from this sample. Two-way analysis of variance (ANOVA) was used in testing significance and Scheffe's post hoc test was used for pairwise comparison between the mean values when ANOVA test was statistically significant. The level of significance was set at $p \leq 0.05$.

Results

The mean values of color changes (ΔE) for the two materials cured by two different light cure at baseline, 1, 7, and 30 days after exposure to ketchup, mustard, Arabic coffee, and distal water as control are summarized in table 2 and figure 1. However, it was statistically not significant (p=0.947). Overall, the highest ΔE was observed with Z350 material, halogen light cure, mustard staining media, and at 30 days time.

Table 2: Mean (Standard Deviation) of the color change value ΔE

Curing mode	Staining Media	Time	Material			
			Z250		Z350	
			Mean	SD	Mean	SD
Halogen	Distilled water	Baseline	1.5150	.54447	.6750	.91217
		1 day	.5500	.46669	.9500	.16971
		7 days	2.2850	2.72236	.9200	.83439
		30 days	.5150	.17678	2.0450	2.22739
	Ketchup	Baseline	2.6200	.80610	1.4150	.34648
		1 day	.7750	.14849	.8450	.57276
		7 days	3.1900	2.67286	1.8950	.68589
		30 days	1.5750	.94045	3.5450	.98288
	Mustard	Baseline	1.6650	.81317	1.8300	.05657
		1 day	7.0900	.97581	10.3100	.57983
		7 days	20.7850	1.11016	32.0150	6.13062
		30 days	27.5600	1.72534	50.1200	9.29138
	Arabic coffee	Baseline	2.3200	.41012	1.4600	.24042
		1 day	1.8750	.81317	3.6050	.50205
		7 days	3.4100	.46669	5.7250	.12021
		30 days	4.4300	.22627	9.5200	.83439
LED	Distilled water	Baseline	3.2150	3.86787	1.0100	.41012
		1 day	1.2300	.33941	.6450	.62933
		7 days	1.6600	.50912	.4850	.30406
		30 days	1.0900	.97581	1.6400	1.66877
	Ketchup	Baseline	1.7100	.25456	2.8750	.41719
		1 day	2.3000	.11314	.8900	.14142
		7 days	.9450	.36062	.6300	.07071
		30 days	1.7200	.16971	1.6800	.39598
	Mustard	Baseline	3.4050	2.22739	2.7100	2.95571
		1 day	6.6550	1.33643	6.7750	.79903
		7 days	15.4400	.22627	21.7400	.35355
		30 days	18.0800	.28284	32.5600	.60811
	Arabic coffee	Baseline	2.3850	2.08597	.9650	.07778
		1 day	3.0450	.82731	2.7100	.31113
		7 days	2.8300	.04243	4.0450	.62933
		30 days	4.4450	.37477	5.7550	.82731

The mean ΔE of Z350 was statistically significantly (p=0.000) higher than Z250 material regardless of curing mode, type of staining media, and time. The mean ΔE of those cured with halogen light cure was statistically significantly (p=0.000) higher than LED light cure regardless of the material, type of staining media, and time. The mean ΔE of those immersed in mustard staining media was statistically significantly (p=0.000) higher than other staining media regardless of the material, curing mode, and time. The mean ΔE of those immersed for 30 days' time was statistically significantly (p=0.000) higher than other time period regardless of the material, curing mode, and type of staining media.

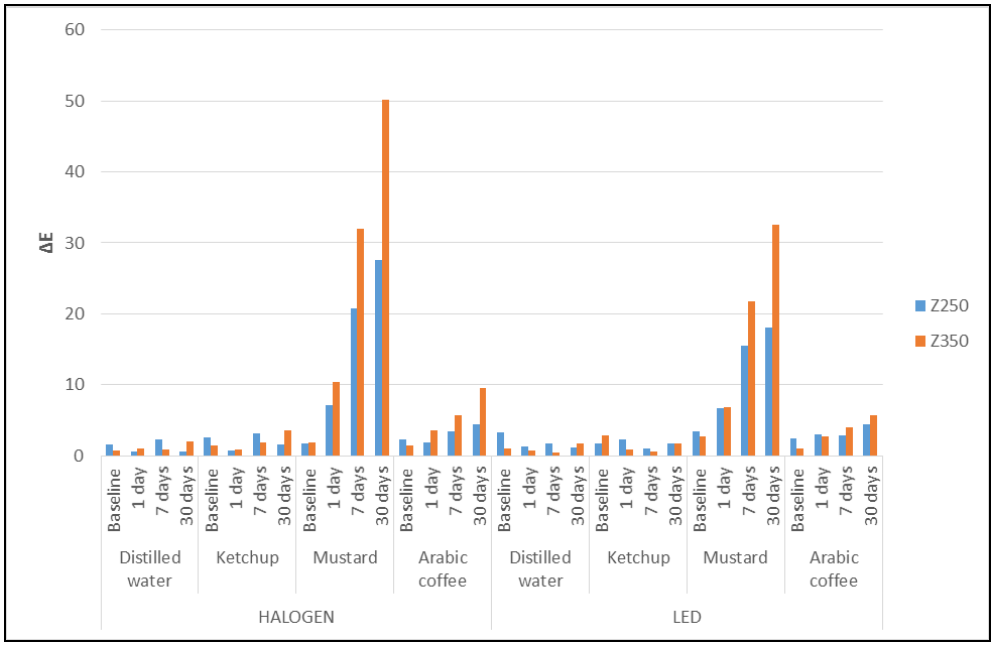

Fig 1: Mean of the color change value ΔE

The interaction between material and light cure (p=0.007); material and staining media (p=0.000); material and time (p=0.000); light cure and staining media (p=0.000); light cure and time (p=0.000); and staining media and time (p=0.000) was found to be statistically significant. On the other hand, interaction between material, light cure, and staining media (p=0.103); and interaction between material, light cure, and time (p=0.234) was not found to be statistically significant. However, interaction between material, staining media, and time (p=0.000); and interaction between light cure, staining media, and time (p=0.000) was found to be statistically significant.

Table 3: Post-hoc analysis for staining media

		Mean Difference	Std. Error	95% Confidence Interval		p value
				Lower Bound	Upper Bound	
Ketchup	Distilled water	.5113	.44270	-.7599	1.7824	.722
Mustard	Distilled water	14.8944	.44270	13.6232	16.1655	.000
	Ketchup	14.3831	.44270	13.1120	15.6543	.000
	Arabic coffee	12.5134	.44270	11.2423	13.7846	.000
Arabic coffee	Distilled water	2.3809	.44270	1.1098	3.6521	.000
	Ketchup	1.8697	.44270	.5986	3.1408	.001

Table 3 and 4 shows the post-hoc analysis for staining media and time. There was statistically significant mean difference (ΔE) between all the staining media except between ketchup and distilled water (p=0.722). Similarly, a statistically significant mean difference (ΔE) was found between all time periods except between one day and baseline (p=0.089).

Table 18: Post-hoc analysis for time

		Mean Difference	Std. Error	95% Confidence Interval		p value
				Lower Bound	Upper Bound	
1 day	Baseline	1.1547	.44270	-.1164	2.4258	.089
7 days	Baseline	5.3891	.44270	4.1179	6.6602	.000
	1 day	4.2344	.44270	2.9632	5.5055	.000
30 days	Baseline	8.4066	.44270	7.1354	9.6777	.000
	1 day	7.2519	.44270	5.9807	8.5230	.000
	7 days	3.0175	.44270	1.7464	4.2886	.000

Discussion

The current study was designed to evaluate the color stability of two different composites resins with same shade using halogen and LED light cure. The present study evaluated how the color of different resin composites behaves over time. The null hypotheses that there is no difference between halogen and LED light cure in color stability of restoration which was evaluated was rejected. It has been reported that different beverages and soaking time are the contributing factors to composite color stability [9]. In the current study, seven and thirty days after the light activation of the resin composite there were significant color changes at all stages in which the color was evaluated. The results of the present study are in agreement with a previous study [7].

The results of the present study provided information on the color stability of resin composites and the staining potential of some commonly consumed products in daily life. Color measurement which is often reported using the CIELAB color system was used. In the present study the color change was compared using three values of ΔE. Previous studies on color stability have reported that values of ΔE higher than 3.3 can be considered clinically unacceptable [10]. The two different materials tested in this study showed color change after 1 day of immersion in ketchup and Arabic coffee. However, these changes were considered clinically acceptable. Both tested materials demonstrated unacceptable color change after 7 days of immersion in mustard.

Very few studies have focused on the effects of some important colored foods that are very common in the patient's diet, such as ketchup and mustard on the color of composites. In this study all solutions especially mustard and Arabic coffee showed visible discoloration in composite. This finding is in line with the findings obtained in other investigations [11-12]. Mustard was the substance that promoted the greatest staining due to curcuma which has a brilliant yellow color and is insoluble in water. Similar findings were observed in previous studies [13]. In 7 and 30 days period, both materials showed immersed in Arabic coffee showed clinically unacceptable discoloration similar to a previous study [14].

Ketchup is very popular condiment among all over the world. The red color is due to a substance called lycopene which is also insoluble in water [15]. However, both materials showed immersed in ketchup showed clinically acceptable discoloration at 1, 7, and 30 days' time period respectively. Specimens immersed in distilled water did not alter the color of the composite to a significant extent which is in agreement with previous studies [12, 16]. The minor color alteration might be due to some water sorption of the organic matrix as distilled water has no pigments.

The discolorations of the composite materials were related to the resin filler type, type of resin matrix, and type of staining agent. Resin composite materials that can absorb water can also absorb other fluids with pigments resulting in discoloration. It is anticipated that water acts as a conductor for the pigment resulting in discoloration [9, 17]. In the present study Z350 revealed highest ΔE values in comparison with Z250. This finding was in contrary with the findings from a previous study [18] where lower coefficient of light transmission due to the various sizes of their particles contributed to the higher values of ΔE for Z250 [19]. In this study, LED light cure revealed highest color stability than halogen light cure which is also in contrary with a previous study [20].

Conclusion

When working in esthetics area, for the clinicians and patients, color stability is an important variable to be considered when choosing composite resin material. It can be concluded that all staining media used in this study affected the color stability of the tested materials with time. The color difference was very high for Z350 material, halogen light cure, mustard staining media, and at 30 days aging time. To assure better color stability and long-term maintenance of the restoration, the clinician should have adequate knowledge on the effects of staining composite and also the post-operative instructions they give their patients. Further studies with longer period of aging are warranted by the findings of this study.

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