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Original Article

Comparative evaluation of the effect of Light Emitting Diode (LED) and Quartz Tungsten Halogen (QTH) light curing units on color stability of Filtek Z350 XT

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Abstract

Introduction: Discoloration of the resin-based composites is a common problem in restorative dentistry. There are many factors associatedwith the discoloration of dental materials in the oral environment. The purpose of this study was to evaluate the color changes in a nano-composite cured with a quartz-tungsten-halogen (QTH) and light emitting diode (LED) unit.

Methods: 80 disk-shaped specimens were prepared using Filtek Z350 XT. The specimenswere cured with two LED units (Valo and BluephaseC5) andQTH (Astralis7)with two different energy density (400 & 750 mW/Cm²). The color of the materials was measured before and after immersingin tea and artificial saliva.Color change value (ΔE) were calculated and analyzed by 2-way ANOVA and Tukey's test.

Results: In artificial saliva group,the compositescured with Astralis7 and BluephaseC5 showed significantly more color stability. In tea group, the composites cured with BluephaseC5 significantly had the least color change.

Conclusions: The type of light curing unitdoes not affectthe color stability. Exposure time and interaction between light source and photoinitiator content in composite may be the most important factors affecting color stability.

Keywords: Dentalcuring lights, Nanocomposite, Spectrophotometry

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ارزیابی مقایسه ای اثر دستگاههای لایتکیور LED و QTH بر ثبات رنگ کامپوزیتFiltek Z350 XT

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چکیده

مقدمه: تغییر رنگ کامپوزیتهای رزینی یک مشکل عمده است. فاکتورهای بسیاری با تغییر رنگ مواد در محیط دهان ارتباط دارند. هدف از این مطالعه ارزیابی تغییرات رنگی یک نانوکامپوزیت است که با منبع نور یک وارتز–تنگستن–هالوژن (QTH) و دیود نوری (LED) کیور شده باشد.

مواد و روش ها: ۸۰ نمونه به شکل دیسک با استفاده از کامپوزیت Filtek Z350 XT آماده سازی شدند. نمونه ها توسط دو دستگاه LED (Valo و BluephaseC5) وQTH (Astralis7) با دو شدت متفاوت (mW/Cm^2 750،400) کیور شدند. رنگ مواد قبل و بعد از غوطه وری در محلول چای و بزاق مصنوعی اندازه گیری شد. میانگین ΔE با استفاده از دو روش آماری ANOVA و تست Tukey ارزیابی شد.

یافته ها: در نمونه های غوطه ور شده در بزاق مصنوعی، نمونه های کیور شده با Astralis7($400mW/Cm^2$) و BluephaseC5 به طورمعنی داری، ثبات رنگی بیشتری را ازخود نشان دادند. و در نمونه های غوطه ور شده در چای، نمونه های کیور شده با BluephaseC5 به طورمعنی داری کمترین تغییرات رنگی را دارا بودند.

نتیجه گیری: نوع دستگاه نوری بر ثبات رنگ اثر ندارد. احتمالاً زمان تابش و تقابل بین نوع دستگاه نوری و آغازگر موجود در کامپوزیت مهمترین فاکتورهای موثر بر ثبات رنگی هستند.

واژگان کلیدی: لایتکیور های دندانپزشکی، نانوکامپوزیت، اسپکتروفتومتری

Introduction

The demand of aesthetic restorative materials has been increased after the introduction of resin-based composites (RBC) from late 1970s. Despite the manyadvantages of RBCs, they have a considerable disadvantage which related to their discolorations in the oral cavity after ages (1, 2).

Many factors affect color change of RBCs in oral cavity. Discoloration may occur by intrinsic or extrinsic factors. Extrinsic discoloration caused by adsorption or/and absorption of colorant agentscontained in beverages, foods, tobacco and chromogenicbacteria. Intrinsic factors contain discoloration of material by itself which isdetermined by the quality of resin matrix, photoinitiators and inorganic filler (3). Numerous studies haveshown that adequate polymerization of RBCs is apparently influential on the physical and mechanical properties such as staining. One of the factors that influences polymerization is light curing unit (LCU), including spectral distribution, exposure time and intensity of light output (1, 4, 5).

Until recently, quartz-tungsten-halogen (QTH) units have been used for polymerization of RBCs. Due to its shortcomings, new technologies introduced for light polymerization of RBCs (6). The Light Emitting

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Diode (LED) technology was introduced in 1995 for polymerization of RBCs to overcome the shortcomings of QTH units. LEDs use junctions of doped semi-conductors instead of the hot filament and have a lifetime 100 times greater than QTHs (7).

Nano-composites have been introduced recently. It has been thought that nanocompositesmay have improvement in their physic-mechanical properties. Also, it has been claimed that low TEGDMA content innano-composites may limit its water uptake and staining susceptibility (8). The purpose of this study was to evaluate the influence of the type of LCU on color stability of a nano-composite after immersing it in a colorant beverage (tea), compared to artificial saliva.

Methods

A nanocomposite, Filtek Z350 XT (3M ESPE, St Paul, MN, USA) of A2 enamel shade was used.80 disk-shaped specimens, 8 mm in diameter and 2 mm in height, were prepared in a siliconering using Filtek Z350 XT composite. The specimens were divided into 4 groups (n=20). One millimeter glass slide was placed over the ring and pressure was applied until the slide touched the RBC completely.

The distance between LCU and specimen was standardized by placing the light-guide tip over the glass slide.

The specimens were cured by Valo (LED), BluephaseC5 (LED) andAstralis7 (QTH) (with two different light intensitiesto Comparison the effect of low and high light intensity in color stability) LCUs (table 1). Because of the different light output of LCUs, their power density was standardized according to the following formula:

Power Density (J/Cm²)=Light Intensity (mW/Cm²)×Exposure Time (S)

The specimens were polished by silicone-carbide paper of 220, 400, 600, 800, 1200 grit for 10^S in a humidity environment to unify the surfaces. Then all the specimens were incubated in 100% humidity at 37˚C for 24 hours.

After this period, the color values of each specimen were measured with an Easy shade spectrophotometer (VITAZahnfabrik, H.Rauter GmbH & Co. KG, D, Germany) in CIE L*a*b system. According to the CIE L*a*b* color system, all colors in nature have three specific basic color coordinates. These color coordinates are L*(lightness), a* (the amount of red and green), and b* (the amount of yellow and blue)(1).

A white card was used as a background when measuring specimens. After measuring the baseline color, half of the specimenswere immersed in tea (Yellow label tea; Lipton, London) which was prepared, immersing two tea bags (2.2 g) into 250 ml of boiling water for two minutes. The other half of the specimens were immersed in artificial saliva (biotène®, Rancho Dominguez, CA, USA). All specimens were incubated at 37 ˚C for 72 hours.

After 72 hours, the color values of each specimen were re-measured, and the color change value (ΔE*ab) was calculated from the differences of the values of L*, a*, and b* according to this formula (1):

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

The data were statically analyzed using two way repeated measures ANOVA and Tukey 's test with SPSS 17 software ($p<0.05$).

Table 1. Light curing unitsused in this study

LCU	Type	Spectral distribution (nm)	Light Intensity (mW/Cm²)	Exposure Time (S)	Power Density (J/Cm²)	Manufacturer
BluephaseC5	LED	430-490	500	32	16000	IvoclarVivadent
Valo	LED	395-480	800	20	16000	Ultradent
Astralis7	QTH	400-500	HIP: 750 LOP: 400	22 40	16500 16000	IvoclarVivadent

Results

The contribution of each basic color coordinates (L, a & b) is shown in figure1. Figure 2 shows the results of the influence of the type of LCU on color stability. The greatest change was found to be the value (L*) rather than chroma (a*, b*) in tea. There was statistically significant difference in color change between the specimens immersed in tea and those immersed in artificial saliva.

The specimens immersed in tea showed clinically perceptible color change and the specimens immersed in artificial saliva had color change which clinically were imperceptible (ΔE<3.3*)*. In artificial saliva, specimens cured with Astralis7 (400mW/Cm²) and BluephaseC5 (LED) showed significantly more color stability. In tea, specimens cured with BluephaseC5 (LED) had the least color change and the other three groups had no statistically different color change.

L*(lightness), a* (the amount of red and green), and b* (the amount of yellow and blue)/ ΔL, Δa, Δb=differences of L*, a*, and b* prior to and after immersing. (Different letters used to show statistical difference between groups)**.**

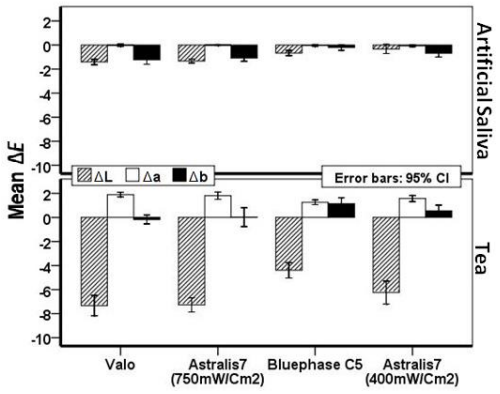


Figure 1. The contribution of each basic color coordinates

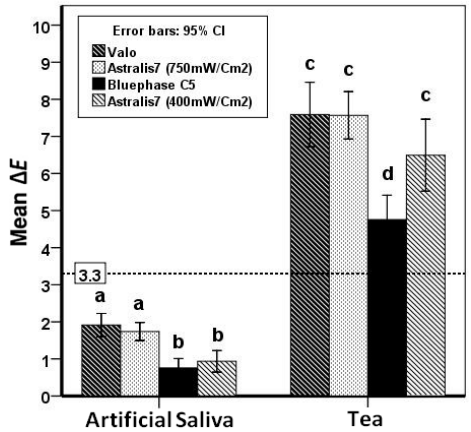


Figure 2. Mean ΔE obtained for specimens cured with QTH or LED sources

Discussion

In this study, color changes of Filtek Z350 XT in two different environments with four different light intensities and LCUs have been calculated. Specimens cured with lower intensity units showed significantly more color stability. Many factors have effect on color changes of RBCs. Resin matrix, dimensions of filler particles, depth of polymerization, oxidation of unreacted carbon-carbon double bonds, degree of conversion and coloring agents may affect the color stability (9, 10).

Color changes of RBCs can be evaluated by visual or instrumental techniques. Spectrophotometry is the most reliable technique in evaluating discoloration of dental materials (11). Instrumental techniques generally use two color systems: the Munsell Color Systemandcommission International de'lEclairage (CIE) Color System (12).

Color evaluation in this study has been evaluated by Vita Easyshade which is a spectrophotometer using CIE L*a*b system. The high reliability of this device in comparison to the laboratory spectrophotometer has been proven in recent studies (13, 14).

According to the individual ability of the human eye, three different intervals of ΔE were used: ΔE<1– imperceptible by the human eye; 1<ΔE<3.3– perceptible only for skilled person; ΔE>3.3 easily observed. ΔE<3.3 is clinically acceptable (15).

In the current study, The color change of specimens in artificial saliva were clinically imperceptible (ΔE<3.3) but those in tea were perceptible (ΔE>3.3), and the difference were statistically significant.

The staining susceptibility of RBCs has been attributed to the hydrophilicity and degree of water sorption of the resin matrix. Water sorption cause expansion and plasticization of the resin component, hydrolyze the silane, and consequently make micro-crack or interfacial gaps at the interface between filler and matrix. These gaps allow stain penetration and discoloration (12, 16).

Thus, color changes of specimens in artificial saliva, which contain water as the basic component, is provable. Moreover, clinically imperceptible discoloration may be attributed to the presence of no pigment in artificial saliva.

If RBCs can absorb water, then they can also absorb other beverages such as tea (12). Discoloration of the RBC in tea was clinically perceptible, similar to previous studies. This color change may beattributed to yellow colorants existing in tea (12, 16). Nasimand et al. (10) claimed that stain ability of tea may be due to

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tannic acid. In artificial saliva, specimens cured with Astralis7 (400mW/Cm²) (QTH) andBluephaseC5 (LED) significantly showed more color stability. Also, in tea, specimens cured with BluephaseC5 significantly had the least color change.

The degree of conversion affecton solubility and color stability of RBCs (9, 10, 12, 17). Some studies reported that time may be the most important factor influencingthe degree of conversion (2, 17, 18, 19). The result of this study was similar to those studies. BluephaseC5 and Astralis7 (400mW/Cm²) had the longest curing time (32 and 40 s).

This may be one of the reasonsthat caused better result for these two LCUs. On the other hand, recent studies have reported that LED technology polymerizes RBCs as well or better than some QTH lights (20, 21-23). Also, in accordance to previous studies, light emitted by LED lamps allows a reduction of the exposure time from that recommended by RBC manufacturers for QTH curing lights (24, 25).

In this study, BluephaseC5 as LED showed the result as similar as the referred studies but Valo was another LED that did not conform to those results. Therefore, other factors might be responsible for better polymerization.

Filtek Z350 XT contains camphorquinone as photoinitiator, (peak absorption at 468 nm) (20, 26, 27). In this study BluephaseC5 had the narrowest spectral range (430-490 nm) which matches with the optimum absorption wavelength for the activation of the camphorquinone, which is in agreement with our study. However, spectral distribution of LCUs may be another factor affecting on the degree of conversion and subsequently, on color stability.

Conclusions

Specimens cured with LED and QTH did not have difference in color stability. But, exposure time and interaction between LCU and photoinitiator contained in composite may be the most important factors affecting color stability. It is suggested to evaluate the effect of different energy density and influence of heat production after light curing, on the stain susceptibility of RBCs.

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Conflict of interest: There was no conflict of interest.

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