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THE EFFECT OF DIFFERENT LED CURING INTENSITIES ON COLOR STABILITY OF NANOFILLED RESIN COMPOSITE

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ABSTRACT

Aim: to evaluate the effect of different LED curing intensities on color stability of nanofilled resin composite.

Materials and methods: nanofilled Resin composite discs specimen (Filtex Z350XT, 3M, ESPE) were prepared and light cured with LED curing unit either standard intensity for 40 sec or high intensity for 20 sec. The specimens' colors were measured (as a base line) using a portable Reflective spectrophotometer (X-Rite, model RM200QC, Neu-Isenburg, Germany) and measurements were made according to the CIE L*a*b* color space relative to the CIE standard illuminant D65. specimens of each group were immersed for one day in tea solution. After immersion the color changes (ΔE) of the specimens were evaluated. Statistical analysis was then performed. As data was parametric, significance of the difference between groups was evaluated using unpaired t test. The level of significance was set at $P < 0.05$.

Results: A higher mean value was recorded with high intensity light curing. Unpaired t test revealed that the difference was statistically significant (p=0.0442).

Conclusions: the different light curing intensities might affect the color stability of nanofilled resin composite. The effect of beverages as staining solutions on color stability of resin composite restoration might be immersion-time and resin material dependent. Nanofilled resin composite with optimum polymerization might show more color stability.

Key words: LED light intensity, nanofilled composite, color stability

INTRODUCTION

One of the most challenges for modern dentistry is to achieve a perfect color matching between tooth structure and tooth-colored restorations. Unfortunately, great improvements have been achieved in recent years but color stability is still a major problem for tooth colored restorations especially resin composite materials [1,2]. It is mandatory for any tooth-colored restorative material to maintain intrinsic color stability and to have resistance to surface staining and discoloration[3]. Discoloration of any restoration could be due to extrinsic or intrinsic causes. Extrinsic causes were

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as accumulation of plaque and surface stains, alterations of surface properties (increase surface roughness), superficial degradation due to wear of the material or a slight penetration and reaction of staining agents within the superficial layer of resin composites [(4)]. Degree of color changes can be affected by a many number of factors like incomplete polymerization, water sorption, chemical reactivity, diet, oral hygiene and surface smoothness and characters of the restoration [(5)]. Consumption of certain beverages such as coffee and Tea or acidic drinks could affect the aesthetic and physical properties of resin composite restorations so negatively affect the esthetic quality of any restoration [(6)]. The effect of such beverages on esthetic of the resin composites is in direct relation with their amount and frequency of their intake [(7)]. The color stability of resin composites is also affected by the composition, size of the filler particles, resin matrix and the incomplete polymerization of resin composite [(8)]. This is may be attributed to chemical degeneration of the filler-resin bond and solubility of the resin matrix [(9)]. Many literatures documented that although the excellency in mechanical and esthetic properties of nanofilled resin composite, this material suffered from color instability regardless the type of staining solutions and their immersion times which could represent a real problem that might face the clinicians as an esthetic restorations[(3,7,10)]. Proper polymerization of resin composites is important for optimum physico-mechanical properties. The quality of polymerization is not only dependent on the chemistry of the resin composite material and the filler particle size, but also on the light curing units, including spectral distribution, exposure time and intensity [(10)]. Thus, this present study was conducted to evaluate the color stability of resin composite restorations after exposure to commonly consumed beverages with different light curing intensities. So the null hypotheses of this study were: the different light curing intensities does not affect the color stability of resin composite.

MATERIALS AND METHODS

Circular Teflon mould (4mm internal diameter x 2mm thickness) was prepared that was placed over glass slab covered with transparent mylar strip. A total number of 16 Resin composite discs specimen were prepared by packing nanofilled resin composite material (Filtex Z350XT, 3M, ESPE) shade A3 inside the mold (table 1), specimens were then covered with mylar strip then 1mm glass slide was pressed gently over it to remove excess material. Specimens were then light cured with LED curing unit (Dr's light AT, Good doctors co.ltd. korea) according to the group division using LED light curing unit using different light intensity. For group 1 (n=8), standard light curing intensity (800 mW/cm2) was used for 40 sec according to the manufacturer instruction. while for group 2 (n=8), high intensity light curing mode (1400 mW/cm2) was used for 20 sec according to manufacturer instruction (table 2).the light intensity was checked every time with radiometer . The curing tips were placed perpendicular to the surface at zero distance to the glass slide to ensure optimum curing. No polishing was performed to avoid any surface modification that may influence the results. Specimens were then stored in artificial saliva at 37^0C in an incubator for a full 24 hours. The specimens' colors were measured (as a base line) using a portable Reflective spectrophotometer (X-Rite, model RM200QC, Neu-Isenburg, Germany). The aperture size was set to 4 mm and the specimens were exactly aligned with the device. A white background was selected and measurements were made according to the CIE L*a*b* color space relative to the CIE standard illuminant D65. After taking the baseline color measurements, specimens of each group were immersed for one day in tea solution (Yellow Label, Lipton, Rize, Turkey) that was prepared by immersing one prefabricated tea bags (2 g) into 250 ml of boiling water for three minutes. After immersion the color changes (ΔE) of the specimens were evaluated using the following formula:

$$\Delta E_{CIELAB} = (\Delta L^{*}2 + \Delta a^{*}2 + \Delta b^{*}2)\ ½$$

Where: L* = lightness (0-100), a* = (change the color of the axis red/green) and b* = (color variation axis yellow/blue) [(11)]. Before each measurement, the immersed specimens were rinsed with water for one minute and dried with absorbent paper.

Statistical analysis

Statistical analysis was then performed using a commercially available software program (SPSS 19; SPSS, Chicago, IL, USA). As data was parametric, significance of the difference between groups was evaluated using unpaired t test. The level of significance was set at $P < 0.05$.

TABLE (1) Composition of the resin composite material used

Resin composite	Filler wt%	Filler volume%	Filler type	Filler size	Monomer composition
Filtek Z350XT, 3M, ESPE, St Paul,MN,USA) Batch#N731284	72.5	55.6	Zirconia/silica	4-11nm zirconia particles with 20nm silica filler	Bis-GMA TEGDMA Bis-EMA UDMA PEGDMA

TABLE (2) Light curing unit used

Light curing unit	manufacturer	Curing mode	Curing intensity profile
Dr's light AT	Good Doctor co. ltd. korea	standard	800 mW/cm^2 (40 sec)
		High intensity	1400 mW/cm^2 (20 sec)

RESULTS

Table 2 represents means and standard deviation of ΔL*, Δa*, Δb* of the two groups. **ΔL* (brightness) value:**

Positive ΔL* indicates that the specimens became lighter, whereas negative ΔL* indicates that the specimens became darker. In this study, both group recorded negative value but high intensity demonstrated ΔL* mean value less than that recorded by standard intensity.

Δa* (change the color of the axis red/green) value

Negative Δa* indicates a shift towards green color whereas positive Δa* indicates a shift towards red color. In this study, both group recorded positive value but high intensity demonstrated ΔL* mean value greater than that recorded by standard intensity.

Δb* (color variation axis yellow/blue) value

Positive Δb* indicates a shift towards yellow color while negative Δb* denotes a shift towards blue color. In this study, high intensity light recorded positive mean value but standard intensity demonstrated negative mean value.

Table 3 represent comparison of color change (ΔE) in Filtex Z350XT after polymerization using high intensity curing mode and standard light curing and after immersion in staining solution. (unpaired t test). Staining was considered clinically

TABLE (3) mean and standard deviation of ΔL*, Δa*, Δb* of the two groups

Light intensity		DL	Da	Db
High	Mean±SD	-1.5±1.6	0.12±0.75	1±1.3
standard	Mean±SD	-2.66±1.4	0.02±0.47	-1.5±1.36

TABLE (4) Comparison of color change (ΔE) using high intensity and standard light curing (unpaired t test)

	HI 20 sec	Standard 40 sec	mean of difference	95% confidence interval of this difference:	standard error of difference	t value	P value
Mean	2.62	3.39	-0.7700	From -1.5177 to -0.0223	0.356	2.1637	0.0442*
Std Dev	0.28	1.09					
Min	2.32	2.14					
Max	3.04	5.26					

Significance level P < 0.05, *significant

unacceptable when the (ΔE) value was greater than 3.3(12). In Filtek Z350 XT cured with LED standard intensity mode (800 mW/cm^2) for (40 sec) no perceptible color change was detected (ΔE <3.3). However, there was perceptible color change when specimens were cured with LED high intensity mode (1400 mW/cm^2) for (20 sec) (ΔE > 3.3) after immersion in tea staining solution. Unpaired t test revealed that the difference was statistically significant (p=0.0442), (Table 3, Fig. 1)

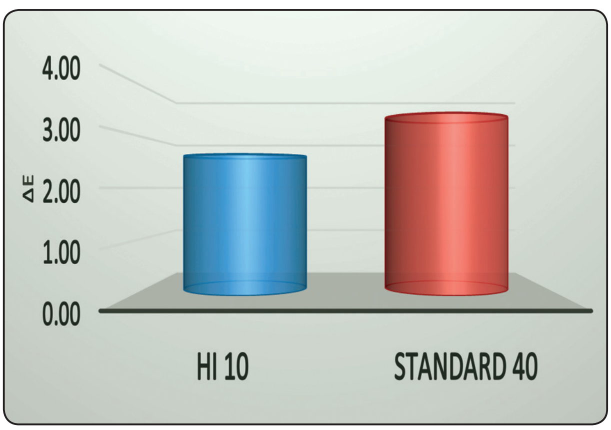

Fig (1) Column chart showing mean color change (ΔE) using high intensity and standard light curing

DISCUSSION

Increasing esthetic demands from patient have been resulted in wide spread use of resin composite restoration as esthetic restorative materials in dental practice. The clinical behavior of resin composite restorative material is greatly affected by its physical, mechanical, and esthetic properties depending on their structure [1,7,10]. In this study nanofilled resin composite restorative material was selected (Filtek Z350 XT) as the manufacturer claims that they have superior physical, mechanical and esthetic properties due to the presence of nanofillers and nanoclusters of silica and zirconia particles as well as their filler amount and their distribution never the less their organic matrix composition (table 1). It's well known that proper shade selection play important role in obtaining optimum esthetic. However, color stability remains real challenge with resin composite material as their major disadvantages remain their color instability which is one of the main reasons for restoration replacement. The human eye cannot detect (ΔE) values of less than 1.5, although this value is measurable with the help of spectrophotometer. Staining was considered clinically unacceptable when the (ΔE) value was greater than 3.3.[11]

The resin composite should be adequately polymerized to achieve its optimum physical and mechanical properties. Underploymerized resin composite may produce undesirable effect such as solubility of unreacted monomer or water sorption that in turns may lead to more staining of the restoration [12]. Therefore, two different curing LED light intensities were selected for this study (table 2).

In the present study it was found that Lightness (ΔL*) decreased in both light intensity group, and Δa* shifted to the red direction for both tested light intensity. Regarding (Δb), there was shifted to the blue direction in standard light intensity group, while the shift was towards the yellow direction high intensity group. These findings suggest that the light curing intensity significantly influence the color stability of nanofilled resin composite materials. Thus, null hypothesis was rejected.

The results of the current study also revealed that the selected nanofilled resin composite was less color stable using the two different intensities of LED light curing modes after immersion in tea staining solution for a full 24 hours that simulate the consumption of this drink over one month, where the means (ΔE) recorded were 2.62± 0.28 for high intensity and 3.39± 1.09 for standard intensity. This could be due to the nature of the resin matrix and the possible porosity in aggregated filler particles as well as the porosity of the glass fillers [7]. Other studies referred the color instability of nanofilled resin composite to that these aggregated filler particles were less color-resistant than the zirconia-silica micron-sized fillers present in Z250 and P60, that might be responsible for high water sorption character of nanofilled resin composite [10].

However, in our study the standard intensity curing mode showed statistically significant color change mean (ΔE) greater than 3.3 that was considered clinically unacceptable when compared to the high intensity curing mode. Some studies reveals that the surface hardness of resin composite obtained with LED light provide an adequate degree of polymerization. Since the degree of conversion might influence the discoloration of composites, a surface with a lower degree of polymerization can exhibit increased discoloration [13,14]. This was not in accordance with other authors that found no significant difference results when comparing LED and QTH light curing unit [10].

So under the limitation of the current study, the following conclusions could be derived:

1- The different light curing intensities might affect the color stability of nanofilled resin composite

2- The effect of beverages as staining solutions on color stability of resin composite restoration might be immersion-time and resin material dependent.

3- Nanofilled resin composite with optimum polymerization might show more color stability.

Recommendation

From the results of this study it is highly recommended to perform optimum polymerization of nanofilled resin composite using high intensity LED curing unit in order to gain a long lasting superior esthetic property of nanofilled resin composite.

Further investigations

More researches are required to investigate the effect of different light curing intensities exceeding 1400 mW/cm^2 on color stability of nanofilled resin composite after immersion in different staining solutions and after different immersion times.

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