



Influence of different types of light curing units and photoinitiators in microhardness and color of composite resins after immersion in wine

Influência dos diferentes tipos de unidade fotoativadoras e fotoiniciadores na microdureza e cor de resinas compostas após imersão em vinho

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ABSTRACT

Objective: the aim of this study is to evaluate the microhardness and color change (ΔE) of composite resins, that were light-cured with different LEDs, after being immersed in a staining drink.

Material and Methods: Two composite resins with Lucerin-TPO (Tetric N-Ceram/ Vit-l-escence) and camphorquinone (Filtek Z350) were selected. The specimens (n=120) were prepared and light-cured with LED of monowave or polywave light-emitting diode (LED) devices. Microhardness and color evaluations were measured before and after immersion in staining drink. Microhardness data were evaluated by Kruskal-Wallis test, Mann-Whitney and Wilcoxon tests. Color changes were evaluated by two-way analysis of variance (ANOVA) and Tukey test ($p \leq 0.05$). **Results:** No statistically significant difference between the two generations of LEDs was found for microhardness data. Regarding the ΔE , a statistical difference between the two LEDs was observed for Tetric N-Ceram and Filtek Z350. **Conclusion:** The composition of composites appears to have more influence on analyses than the type of LEDs used. A decreased microhardness occurred to Vit-l-escence for monowave and to Filtek Z350 for both LED devices. A clinically perceptible color change was observed for Tetric-N Ceram and Filtek Z350 when polywave LED were used.

KEYWORDS

Composite resins; Curing lights; Dental resin; Photoinitiators; Resin photoinitiators.

RESUMO

Objetivo: o objetivo deste estudo foi avaliar a microdureza e alteração de cor (ΔE) de resinas compostas, fotoativadas com diferentes LEDs, imersas em bebidas pigmentadas. **Material e métodos:** Duas resinas compostas com Lucerina-TPO (Tetric N-Ceram/ Vit-l-essence) e canforoquinona (Filtek Z350) foram selecionadas. Os espécimes (n=120) foram preparados. Os mesmos foram fotopolimerizados com LED monowave ou polywave. Microdureza e cor foram avaliadas antes e após a imersão em bebidas pigmentadas. Os dados de microdureza foram avaliados pelos testes de Kruskal-Wallis, Mann-Whitney e Wilcoxon. As alterações de cor foram avaliadas por análise de variância a dois critérios (ANOVA) e Tukey ($p \leq 0,05$). **Resultados:** Não foi encontrada diferença estatística entre as duas gerações de LEDs, para os dados da microdureza. Quanto ao ΔE , foi encontrada diferença estatisticamente significativa entre os dois LEDs, sendo observadas na Tetric N-Ceram na Filtek Z350. **Conclusão:** A composição das resinas compostas parece ter mais influência nas análises do que o tipo de LEDs. Uma redução na microdureza ocorreu para Vit-l-escence para monowave e para Filtek Z350 para ambos os dispositivos LED. Uma mudança de cor clinicamente perceptível foi observada em Tetric-N Ceram para polywave e Filtek Z350 para ambos os dispositivos LED.

PALAVRAS-CHAVE

Fotoiniciadores; Fotoiniciadores dentários; Luzes de cura dentária; Polimerização; Resinas compostas.

INTRODUCTION

Camphorquinone has traditionally used in composite resins whose activation peak occurs at a wavelength of approximately 460nm [1]. However, its intense yellow color has limited its use, particularly in resin materials used for bleached teeth [2]. Thus, other photoinitiators have been used for these materials, such as phenylpropanodione and Lucerin-TPO [2]. A composite resin with deficiencies in the polymerization of the organic matrix undergoes degradation and hence changes in their mechanical properties, making them more susceptible to reduced mechanical strength and color stability [3-5].

Intrinsic and extrinsic sources can influence the color stability of composite resins. The intrinsic factors are resin matrix composition, type of photoinitiators, filler, particle size distribution and degree of conversion. The extrinsic factors are ambient, heat, water, and food stains [3]. Previous studies on color stability have shown that colored beverages such as coffee, soda, tea and wine cause different degrees of staining on composite resins [3].

Polywave light-emitting diodes (LED) emits a light spectrum with varying wavelength from 385 to 515 nm [6,7]. This feature permits the curing of composite resins even when these contain different photoinitiators [8]. Composite resins to bleach teeth may be more susceptible to color change because they usually contain different photoinitiators which can influence on their curing and consequently in their properties [8,9]. The

literature is scarce on studies evaluating the microhardness and color change of composite resins for bleached teeth, using polywave LEDs.

Thus, the aim of this study is to evaluate the microhardness and color stability of composite resin to bleach teeth, photocured by two generations of light curing devices after immersion in wine. The null hypotheses tested was that there was no statistical difference in microhardness and color change between two types of composite resins cured by two generations of LED light, when used for curing composites for bleached teeth after immersion of the specimens in the staining solution.

MATERIAL AND METHODS

Specimen Preparation

Three composite resins were used: two contain camphorquinone and Lucerin-TPO (Tetric N-Ceram shade A1, Ivoclar Vivadent, Schaan, Liechtenstein and Vit-l-escence shade WO Ultradent Products Inc., South Jordan, UT, USA) [2,8], and another only camphorquinone as negative control (Filtek Z350 shade WD, 3M ESPE Dental Products™, St. Paul, MN, USA). Two types of LED devices were used: monowave (Radii, SDI, Victoria, Australia) and polywave (Valo, Ultradent, Products Inc., South Jordan, UT, USA). The composite resins and LED devices are described in Table 1.

Table 1 - Composite resins and curing light LEDs were used in this study

Materials	Color	Composition	Mean particle size	% Filler (by vol)	Manufacturer
Tetric N- Ceram (nanohybrid)	A1	Bis-GMA, UDMA, TEGDMA, barium glass, barium glass and aluminum, highly disperse silica, mixed oxides, prepolymers	40 nm 3000 nm	55-57%	Ivoclar Vivadent, Schaan, Liechtenstein
Vit-I-escence (micro-hybrid)	WO	BisGMA, barium borosilicate and other fillers, camphorquinone, an amine co-initiator and a proprietary initiator	0.7 μm	58%	Ultradent Products Inc., South Jordan, UT, USA
Filtek Z350 (nanofill)	WD	Bis-GMA, Bis-EMA6, UDMA, TEGDMA, zirconia, silica and camphorquinone	5-20 nm n. ag. 0.6-4 μm ag.	59.5%	3M/ESPE Dental Products, St Paul, MN, SA
Curing Light	Type	Wavelength	Intensity	Manufacturer	
Valo	Third generation or Polywave	395-480 nm	~1000 mW/cm ²	Ultradent Products Inc., South Jordan, UT, USA	
Radii- Cal	Second generation or monowave	440-480 nm	~1200 mW/cm ²	SDI Limited, Victoria, Australia	

Twenty discs for each material were obtained using a Teflon matrix (5 mm diameter \times 1.5 mm thick). The resin composite was then inserted into one increment and covered with a glass slide. Then, ten specimens from each resin were photo-cured by the monowave or polywave LED device for 40 s. Planning and polishing were performed with silicon carbide sandpaper in the order of decreasing granulation (# 600 and # 1200). Diamond polishing suspension (1 μm) was applied with a felt disc for final polishing for 60 s (APL-4, Arotec S.A. Ind Com, Cotia, SP, Brazil). The samples were washed for 10 min in an ultrasound device (Cristófoli, Campo Mourão, SP, Brazil), then kept at 100% relative humidity at 37 °C for 24 h.

Microhardness Analysis

The samples were subjected to microhardness analysis (Shimadzu HMV 2000, Shimadzu Corporation, Kyoto, Japan) using a Knoop diamond under 25 g for 30 s. Five indentations were made with 100 μm distance between each indentation. Thens, the arithmetic mean was calculated.

Color Change

Color change ΔE analysis was performed using a reflection spectrophotometer (UV Visible, Model UV-2450, Shimadzu, Kyoto, Japan). The ΔE was calculated using the CIE $L^* a^* b^*$, established by the Commission Internationale l'Eclairage – (CIE). The axial “L” is known as luminosity, which ranges from 0 (black) to 100 (perfect white). The coordinate “a” represents the amount of red (positive values) and green (negative values), while the coordinate “b” is the amount of yellow (positive value) and blue (negative values). Five readings were taken for each surface and the an average of the readings was obtained. To standardize the reading area, the samples were always positioned in the same way.

Immersion of the specimens in the staining solution

The specimens from each group were immersed individually in vials containing 10 ml of red wine (Concha y Toro, Cabernet Sauvignon, pH=3.41; Chile) for one week, which is equivalent to seven months to

immersion [10]. After this period, the specimens were rinsed in distilled running water for 3 min and immersed in 10 ml of distilled water for 24 h at 37 °C.

Final Microhardness and Color Analyses

The same microhardness and color analyses were performed as described above. The differences in the L^* (ΔL), a^* (Δa), and b^* (Δb) values were determined and the overall color change was calculated: $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$.

Statistical Analysis

The software StatView version 5.0 (SAS Institute, Cary, NC, USA) was used for statistical analysis. The assumptions of equality of variances and normal distribution of data were checked using the Bartlett and Shapiro-Wilk tests, respectively. Since homogeneity was not achieved, the microhardness results were analyzed using the Kruskal-Wallis test, followed by the Mann-Whitney test for multiple comparisons. To compare the evaluations times of microhardness the Wilcoxon test was used. Color changes were evaluated by two-way analysis of variance (ANOVA) and the Tukey test for multiple comparisons. The significance level was set as 5%.

RESULTS

Comparison of the composite resins before immersion in wine, showed that Vit-l-escence (Monowave LED $p = 0,0011$, Polywave LED $p = 0,0350$) and Filtek Z350 (Monowave LED $p = 0,0002$, Polywave LED $p = 0,0006$) composite resins had statistically superior microhardness values compared with Tetric N-Ceram for all conditions, rejecting the null hypotheses (Table 2). No statistically significant difference between the two generations of LEDs was found for microhardness data (Table 2). There was

a statistically significant decrease between the baseline and final periods when the monowave device was used for Vit-l-escence ($p = 0,0469$) and Filtek Z350 ($p = 0,0218$) composite resins, and when the polywave device used for Filtek Z350 ($p = 0,0051$) composite resin (Table 2).

Table 2 - Results regarding the baseline and final microhardness measurement of groups submitted to wine

		Tetric-N Ceram	Vit-l- escence	Filtek Z350
Baseline	Radii- Cal Monowave	61.47 ± 3.4 ^{ab}	71.66 ± 3.1 ^{aA}	73.24 ± 6.9 ^{aA}
	Valo Polywave	63.87 ± 5.3 ^{ab}	68.89 ± 4.8 ^{aA}	72.54 ± 3.9 ^{aA}
Final	Radii- Cal Monowave	59.15 ± 2.6 ^{aB}	68.33 ± 2.2 ^{aA*}	67.13 ± 4.2 ^{aA*}
	Valo Polywave	59.74 ± 3.2 ^{aC}	68.33 ± 1.8 ^{aA}	65.70 ± 1.9 ^{ab*}

Equal letters indicate no statistically significant differences. Lowercase referring in columns and uppercase referring in rows. * Indicate a statistically significant difference between the baseline and final periods.

Regarding the ΔE , there was no statistically significant difference between the two generations of LEDs studied for Vit-l-escence composite resin ($P = 0,798$), which had the lowest ΔE values (Table 3). Comparison of the composite resins showed, a higher ΔE value for Filtek Z350, using the monowave device. However, when the polywave device was used, Filtek Z350 and Tetric-N Ceram had similar ΔE values ($p = 0,979$, Table 3). The Δa values presented no statistically significant difference for LEDs type ($p = 0,855$). However, for the ΔL and Δb values when differences were found opposite performances occurred according to different composites (Table 3). Comparison of the composite resins showed no difference for ΔL ($p \leq 0,05$, Table 3).

Table 3 - Results for the overall color change of groups immersed in red wine

	Tetric-N Ceram				Vit-I-escence				Filtek Z350			
	ΔL	Δa	Δb	ΔE	ΔL	Δa	Δb	ΔE	ΔL	Δa	Δb	ΔE
Radii-Cal	-0,98	0,29	1,73	2,86±0,6	-0,73	0,11	0,99	2,13±0,8	-1,52	-0,01	3,88	4,97±1,0
Singlewave	aA	aB	aB	aA	aA	aAB	aA	aA	bA	aA	bC	bB
Valo	-0,79	-0,08	3,01	4,14±0,7	-0,75	0,19	1,23	2,26±0,7	-1,47	0,23	3,37	4,07±1,1
Polywave	aA	aA	bB	bB	bA	aAB	aA	aA	aA	aB	aC	aB

Equal letters indicate no statistically significant differences. Lowercase referring in columns and uppercase referring in rows in each color parameter

DISCUSSION

The evaluation of mechanical and physical properties can provide an indirect measure to preview the monomers conversion in composite resins, such as microhardness and overall color change (ΔE) [8,9]. Although no differences were found for surface microhardness between both LED devices, differences were observed for color parameters, thus rejecting the null hypothesis.

Some studies that evaluated the same composite resins used in the present study also did not find differences in surface microhardness between the monowave and polywave LEDs [8,9]. However, other studies that evaluated composite resins with Lucerin-TPO showed higher microhardness with the polywave than monowave LEDs [11-13]. In the present study, a significant reduction in microhardness for Vit-I-escence photocured by the monowave LEDs occurred after immersion in wine. This attributed to the acidic pH and presence of alcohol in wine, which can affect the unreacted monomers of the composite resin [14,15]. The composition may also influence because the resins for bleaching teeth contain other initiators combined with camphorquinone [16,17].

Evaluation of the composite resins photocured by the same device showed microhardness values superior to that of the nanoparticulate resin (Filtek Z350) before

immersion in wine, corresponding to the literature [16-18]. There are two forms of inorganic particles in all nanoparticulate resins: dispersed - silica particles, measuring approximately 20 nm; and adhering, silica-zirconia nanocomplexes that, behave as a single structure, measuring an average of 75 nm [16]. The union of these two forms provides a higher percentage of charged particles, providing the material with greater resistance, compared with nanohybrid and microhybrid resins, which tend to be less resistant because they have fewer filling agents [17]. However, a significant decrease in microhardness occurred after the immersion of the nanoparticulate resin in red wine. This composite resin contains the TEGDMA monomer, which has greater capacity for water absorption compared with other types monomers (Bis-GMA and UDMA), making it more susceptible to the degradation of unreacted monomers [19].

The physicochemical properties of the monomers used in the resin matrix can also influence the resistance to pigmentation, resulting in overall ΔE [3]. Various methods can be used to assess color, such as guide scales, image analysis, colorimeter or spectrophotometers. Since spectrophotometers allows objective assessment and provide accurate quantitative data, the method was chosen for this study [20].

For the specimens immersed in wine, the acidic pH may have been responsible for the color change by altering the surface roughness of the specimens, however more studies are needed to confirm this possibility [21]. The results obtained in the present study contradict the literature i.e. it was observed that the higher the action spectrum of curing light, the greater the scope of the monomers, promoting better polymerization, and less degradation of the organic matrix and composite pigmentation [22]. The present results were not homogenous with regard to these aspects. This because for one type of composite resin (Vit-l-escence) LED units had no influence for the other tyoes (Tetric-N Ceram and Filtek Z350) opposite behaviors occurred.

ΔE indicates the relative overall color change and according to Inokoshi et al. [22], the values of $\Delta E < 1$ are regarded as unseen by the human eye. Values $1 < \Delta E < 3.3$ are considered noticable skilled operators, but clinically acceptable. Values of $\Delta E > 3.3$ are considered clinically unacceptable [23]. Vit-l-escence resin showed the lowest ΔE , and was clinically acceptable ($\Delta E < 3.3$). This composite resin is the only one among the other composites tested that does not contain TEGDMA monomer. It has greater capacity for water absorption as cited above, causing the resin to be more susceptible to pigmentation [19].

Separating the parameters, opposite behaviors of composite resins were noted when photocured by different LEDs. Changes in the *L parameters can occur because the acidic pH of wine may reduce the surface gloss and consequently the lightness of color [14]. Furthermore, the complex combination of pigments presents in wine, such as anthocyanins that can range from red through blue to purple, can form complexes

with some oral proteins, causing tongue and tooth discoloration, varyng the *a and *b parameters [20,21,24,25].

It is important to emphasize that although the shades of composite resins for whitened teeth were used, these shades were not the same for all composite resins because theses resins had confirmation in the literature about their photoinitiators, being a limitation of this study. Furthermore, the literature has shown studies where composites were manipulated in the laboratory in an attempt quantify photoinitiators and standardize composite resin samples [26,27]. Schneider et al. [27], showed that formulations containing TPO exhibited higher reactivity than that with camphoroquinone but lower depth of cure. However, this does not agree with the pratical experiences of dentists, demonstrating the high medical character and relevance of the present study, with its focus on using resins commonly found in the dental market. Moreover, additional studies are necessary to evaluate other properties of composite resins when photocured by different light-curing units.

CONCLUSION

In general, the composition of composite resins had more influence on microhardness and color change than the type of light-curing units used. A decreased microhardness occurred to Vit-l-escence for monowave and to Filtek Z350 for both LED devices. A clinically perceptible color change was observed to Tetric-N Ceram for polywave and to Filtek Z350 for both LED devices.

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Declaration of conflicting interests

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