



The impact of at home and in-office bleaching agents on the color stability of bulk-fill composite resins

Impacto de agentes clareadores caseiros e de consultório na estabilidade de cor de resinas compostas bulk fill

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ABSTRACT

Objective: This study compared different composites for color stability after exposure to at home and in-office bleaching gels. **Material and Methods:** Composite resin specimens (6mm diameterx2mm thickness) were manufactured according to the following groups (n=20): RC- Conventional; BF-Bulk Fill; RF-Flow; BFF-Bulk-Fill Flow. The surfaces were stained with coffee solution for 36h. A spectrophotometer was used to record the initial color (L*a*b*). Half of the specimens from each group underwent bleaching with 35% hydrogen peroxide (in-office) in three 45-minute applications. New color measurements were performed after 7, 14 and 21 days. The other half of the specimens underwent bleaching with 22% carbamide peroxide (at home) in 14 1-hour applications. Further color measurements were performed after 7 and 14 days. For comparison between the color coordinates in different periods, ANOVA for repeated measures was applied ($\alpha=5\%$). The color variation (ΔE) was calculated for each group. **Results:** For in-office bleaching, there were no significant differences between the periods b* coordinate of the RF group, and for L* and b* coordinates of the BFF group. For at home bleaching the groups BF and BFF showed no differences for the L* coordinate. For the other coordinates, there was difference between the initial periods and after 14 days. The ΔE variation presented higher values for the at home bleaching groups. For both whiteners the bulk-fill resins presented the greatest color variations. **Conclusions:** Bulk Fill resins do not guarantee greater color stability than the other composite resins tested, including conventional flow resin. The conventional composite resin showed the lower ΔE .

KEYWORDS

Color Perception; Composite Resins; Color; Tooth Bleaching; Hydrogen Peroxide.

RESUMO

Objetivo: Esse estudo comparou diferentes resinas compostas quanto a estabilidade de cor após exposição a géis clareadores de uso caseiro e de consultório. **Material e Métodos:** Espécimes de resina composta (6mm diâmetro x 2mm espessura) foram confeccionados de acordo com os seguintes grupos (n=20): RC- Convencional; BF-Bulk Fill; RF-Flow; BFF-Bulk-Fill Flow. As superfícies foram manchadas com solução de café por 36 horas. Um espectrofotômetro foi utilizado para mensurar a cor inicial (L*a*b*). Metade dos espécimes de cada grupo foi submetida ao clareamento com peróxido de hidrogênio 35% (clareamento de consultório) durante três aplicações de 45 minutos. Novas mensurações de cor foram realizadas após as aplicações de 7, 14 e 21 dias. A outra metade dos espécimes foi submetida ao clareamento com peróxido de carbamida 22% (clareamento caseiro) em 14 aplicações de 1 hora durante 14 dias. Novas mensurações de cor foram realizadas após 7 e 14 dias. Para comparação entre as coordenadas nos diferentes períodos foi aplicada a análise de variância ANOVA para medidas repetidas ($\alpha=5\%$). A variação de cor (ΔE) foi calculada para cada grupo. **Resultados:** Para o clareamento de consultório não houve diferenças significativas para a coordenada b* do grupo RF, e para L* e b* no grupo BFF. Para o clareamento caseiro os grupos BF e BFF não apresentaram diferenças para a coordenada L*. Para as outras coordenadas, houve diferenças entre os períodos inicial e após 14 dias. A variação de ΔE apresentou maiores valores para o grupo submetido ao clareamento caseiro. Para ambos clareadores a resina composta bulk fill apresentou as maiores variações de cor. **Conclusões:** As resinas compostas bulk fill não garantiram uma maior estabilidade de cor quando comparadas as resinas compostas tradicionais testadas, incluindo a resina flow. A resina composta convencional apresentou a menor variação de ΔE .

PALAVRAS-CHAVE

Color perception; Resinas compostas; Cor; Clareamento dental; Peróxido de hidrogênio.

INTRODUCTION

Composite resins have been favored as restorative material over the years because they have advantageous properties for use in clinical practice, such as the coefficient of thermal-linear expansion, which is highly compatible with dental structure, higher compressive strength values, acceptable modulus of elasticity and hardness, as well as an excellent aesthetic result. [1]

For the use of composite resins, the insertion was carried out in increments of 2mm at most, respecting cavity configuration factors, following the so-called incremental technique [2]. The main reasons for using this technique are to allow light penetration of the photopolymerizer throughout the depth of the layers, as well as to decrease polymerization contraction and associated stress [3]. In this way, the possibilities of any failure in marginal sealing, cusp deflection, microleakage and consequent appearance of secondary caries are reduced [2].

Despite the advantages of the incremental technique, it also has limitations, such as the greater possibility of incorporation of voids or debris between layers, an increase in the probability of adhesive failures between layers and greater difficulty of insertion in conservational preparations [3-5].

In response to these limitations, bulk-fill composite resins were developed as an alternative. They have increased translucency, which allows the light from the light curing device to reach greater depths in the material without requiring insertion in small increments [5], and portions of up to 5mm (bulk insertion) can be polymerized. In addition, bulk-fill resins have a prolonged pre-gel phase, resulting in greater ease of flow and adaptation at the margins of the cavity, decreasing the clinical time and the induction of stress resulting from their contraction [6].

In addition to making the restorative procedure faster, the development of bulk-fill resins resulted in the addition of a high percentage load (approximately 60% of the volume) in a combination of nanoparticles and larger particles. This structural change results

in less polymerization contraction and stress induction; its polymerization has been shown to be more efficient, increasing its mechanical properties and reducing the cytotoxicity related to the lack of conversion of monomers to polymers.

Studies have been testing important factors for the determination of the behavior of bulk-fill resins in the face of the challenges and conditions to which they will be exposed when in the oral medium [6], and have resulted in promising conclusions when compared to conventional resins [7,8]; the reduction of porosity due to ease of insertion in the cavity, fracture resistance, dentin adhesion and preservation of marginal integrity [4]. However, because it is a recently introduced material on the market, there are still several questions to be answered.

For a composite restoration to be successful, it depends on the surface properties, color and stability of the material. [9] The color change is a recurring cause of the aesthetic failure of composite resin restorations. The degree of color change can be affected by diet, load and organic matrix characteristics, degree of polymerization and water absorption, as well as finishing and polishing procedures, which influence the quality of the resin surface and may be related to the initial discoloration [4].

In addition to discoloration due to changes in the properties of the material due to contact in the oral environment, changes may be caused by exposure to chemical substances, such as bleaching gels. Restorations in the anterior region and up to the 2nd premolars are subject to the action of these agents because they are areas routinely included in bleaching procedures.

Carbamide peroxide and hydrogen peroxide in varying concentration gels are used as bleaching agents for at home and in-office use respectively. Both penetrate the dental enamel until reaching the enamel-dentin interface [7,10]. Free radicals resulting from the decomposition of these peroxides oxidize the pigment molecules, breaking them into smaller, non-pigmented molecules, thus making the teeth visually cleaner [8,11,12]. As they act on the dental structure, possible effects of carbamide peroxide and hydrogen peroxide can

occur on the structure of the composite resin, since their active mechanism involves chemical processes [11].

Based on the above, this study aimed to compare resins with different matrices, being: bulk-fill (conventional and fluid) with composite resins (conventional and fluid), for color stability after exposure to bleaching gels based on hydrogen peroxide 35% and carbamide peroxide 22%.

MATERIALS AND METHODOLOGY

The compositions and trademarks of the composite resins used are described in Chart 1.

Chart 1 - Commercial names, manufacturers and composition of the composite resins and bleaching agents used.

Commercial name	Manufacturer	Composition
Filtek Z350 XT	3M ESPE, St. Paul, MN, USA	Treated silanized ceramics, silane treated silica, UDMA, Bis-GMA, zirconia ceramics, TEGDMA, Bis-EMA. The inorganic filler loading is hb approximately 72.5% by weight (55.5% em volume)
Filtek Bulk Fill	3M ESPE, St. Paul, MN, USA	Ceramics treated with silica, UDMA, ytterbium trifluoride, silane treated silica, DDDMA, silica treated zirconia, water, EDMAB, benzotriazole, titanium dioxide, pentanedioic acid, 2,2-dimethyl-4-methylene, reaction product with glycidyl methacrylate The inorganic filler loading is approximately 76.5% by weight (58.4% by volume)
GrandioSO Flow	VOCO, Cuxhaven, Germany	1,6 hexane diylbis methacrylate, Bis-GMA, Bis-EMA, TEGDMA The inorganic filler loading is approximately 81% by weight
Filtek Bulk Fill Flow	3M ESPE, St. Paul, MN, USA	Treated silanized ceramics, UDMA, substituted dimethacrylate, Bis-EMA, ytterbium trifluoride, Bis-GMA, benzotriazole, TEGDMA, ethyl 4-dimethylaminobenzoate The inorganic filler loading is approximately 64.5% by weight (42.5% by volume)
Whiteness Perfect 22%,	FGM, Joinvile, SC, Brazil	Peróxido de Carbamida, Carbopol Neutralizado, Nitrato de Potássio, Fluoreto de Sódio, Umectante (Glicol), Água Deionizada.
Whiteness HP 35%,	FGM, Joinvile, SC, Brazil	Peróxido de Hidrogênio a 35%, Espessante, corante vermelho, glicol e água.

TEGDMA = Tetraethyleneglycol Dimethacrylate
UDMA = urethane dimethacrylate
Bis-GMA = bisphenol A diglycidil dimethacrylate
Bis-EMA = ethoxylatedbisphenol A dimethacrylate
DDDMA = 1,10-decandiol dimethacrylate
EDMAB = Ethyl 4-(dimethylamino)benzoate

80 standard specimens with the dimensions of 6mm diameter and 2mm thickness were made using a silicon matrix in composite resin according to the groups described below:

- Group RC (Control) - Conventional composite resin (n = 20)
- Group BF - Bulk Fill composite resin (n = 20)
- RF Group - Conventional Flow Resin (n = 20)
- BFF Group - Bulk Fill Fluid Resin (n = 20)

The composite resin was applied to the silicon matrix with a non-stick resin spatula in the RC and BF groups. For the RF and BFF groups the material was applied through cannulas supplied by the manufacturers. The specimens were made in a single layer and photoactivated for 20s. (Raddi Cal, SDI). After the restorations were made, the specimens were stored in distilled water in an oven at 37°C for 48h, so that post-curing of the resins could occur.

After the waiting period, the specimens were coupled to a metal matrix with a specific hole to fit them, allowing them to be properly fixed and for one of their faces to be polished with a circular polishing machine (DP-10, Panambra, São Paulo, SP, BR) at 300rpm rotation while subjected to water refrigeration.

The surfaces were sandblasted in the following sequence: #600 for 30s, #800 also for 30s. and #1200 for 2min.

Surface staining

To evaluate the action of hydrogen peroxide and carbamide peroxide in vitro on the color of the resins, the surfaces of the specimens were stained with a coffee solution. A portion of 1 teaspoon of soluble coffee (Nescafé, Nestlé, Brazil) was mixed in 50ml of hot water (80 °C) to prepare the coffee solution. The solution was stored in a capped vial under refrigeration at 5°C.

The specimens were placed in silicon bases with the polished faces upwards and then immersed in the coffee solution for 36h, during which time they were stored in closed bottles in a bacteriological oven at 37°C.

After the staining period the specimens were washed with ultrasound with distilled water for 5min to remove residues.

Preliminary Color Reading

A spectrophotometer (Vita EasyShade®, VITA-Zahnfabrik H. Rauter GmbH & Co. KG, Bad Säckingen-Germany) was used to record the color of the resin specimens, consisting of a module with a handpiece with three separate spectrometers and 19 optical fibers of 1mm diameter, protected by stainless steel. The outer fibers transmit the light to the tooth and the inner fibers receive reflected light and act as sensors. The equipment has a central processing unit that analyzes the spectrophotometer data, determining the color in comparison to the VitaPAN Classical (Vita Zahnfabrik, Bad Säckingen, Germany) and VITA Toothguide 3D-MASTER® scales (Vita Zahnfabrik, Bad Säckingen, Germany), providing the values of the chromatic coordinates L^* , a^* , b^* , L^* , C^* and h^* . The spectrophotometers were properly calibrated following the manufacturer's specifications prior to each use and the lighting was kept constant (illuminant D65, which corresponds to daylight) and was standardized during all measurement procedures.

Application of Bleaching Gels

Half of the specimens from each group ($n = 10$), were randomly assigned to the bleaching challenge with 35% hydrogen peroxide (in-office), while the other half were challenged with carbamide peroxide 22% (at home).

Application of Carbamide Peroxide Whitening Gel 22%

Half of the specimens from each group ($n = 10$) were submitted to the bleaching challenge with Carbamide Peroxide 22% (Whiteness Perfect 22%, FGM). For this, the bleaching gel was applied on the surface of the samples, positioned in a silicon matrix, with an applicator tip coupled to the syringe provided by the manufacturer (Figure 1). After one hour the bleaching gel contents were removed with a surgical sucking device coupled to the vacuum pump, and the surfaces cleaned under running water. The procedure was repeated for

14 days as recommended by the manufacturer. During the bleaching challenge phase and in the periods before and after the tests the samples were immersed in distilled water and stored in a bacteriological oven at 37°C. After the periods of 7 and 14 days a new color measurement was performed, so that data regarding the initial periods were obtained after 7 and 14 days of exposure to the bleaching agent.



Figure 1 - Gel syringe based on Carbamide Peroxide 22% and gel applied on the samples.

Application of Hydrogen Peroxide Whitening Gel 35%

Half of the specimens from each group ($n = 10$) were subjected to a bleaching challenge with 35% Hydrogen Peroxide (Whiteness HP 35%, FGM) prepared according to the manufacturer's guidelines (Figure 2). Three applications of 15min were performed, among them the bleaching gel content was removed with a surgical sucking device coupled to a vacuum pump. Bleaching procedures were performed in 3 sessions with a 7-day interval between them. At these times and before the beginning of the tests the samples were immersed in distilled water and stored in a bacteriological oven at 37°C. Between each session and after the last one, a new color measurement was performed, so that data was obtained for the initial periods, 7, 14 and 21 days.



Figure 2 - 35% Hydrogen peroxide-based bleach: Bottles (hydrogen peroxide on the left, thickener on the right), contents of the jars homogenized in gel (top center), and gel applied to the samples.

Statistical analysis

To compare the color of specimens, ANOVA for repeated measures ($\alpha = 5\%$) was performed for coordinates L^* , a^* and b^* at the different time periods. The variation of color composition or total color variation, designated by ΔE , was calculated using the following formula:

$$\Delta E = [(L^* \text{ final} - L^* \text{ initial})^2 + (a^* \text{ final} - a^* \text{ initial})^2 + (b^* \text{ final} - b^* \text{ initial})^2]^{0.5}$$

RESULTS

The results presented refer to the measurements obtained by the color readings of the samples with spectrophotometer, corresponding to the values of ΔL - luminosity: difference between white and black, Δa - change between red and green, and Δb - change from yellow to blue.

The variance analysis (ANOVA) for repeated measures ($p < 5\%$) was applied to provide the response in which of the coordinates (L^* , a^* and b^*) significant color variation

occurred, separately for each experimental group. The Tukey test was applied to those groups that presented significant differences in the ANOVA test, showing between which of the periods any significant variation occurred.

The data obtained for the 35% Hydrogen Peroxide subgroup is shown in Table 1, where the values of the CIEL* a^* b^* system coordinates can be observed for each experimental group, indicating that there were significant differences between the periods for all the groups, except for the b^* coordinate of the RF group, and for the L^* and b^* coordinates of the BFF group.

Table 1 - Mean, standard deviation and ANOVA test results ($p < 5\%$) for repeated measures and Tukey test (superscript) for each of the coordinates (L^* , a^* and b^*) and periods (initial, 1st, 2nd and 3rd sessions of whitening) for the In-office Bleaching subgroup (hydrogen peroxide 35%)

GROUP	COORDINATE	INITIAL AVERAGE	7 DAYS AVERAGE	14 DAYS AVERAGE	21 DAYS AVERAGE	ANOVA
RC	L^*	68.43 (4.74) ^A	73.61 (4.57) ^B	76.71 (4.94) ^{BC}	77.21 (5.3) ^C	$P < 0.0001^*$
	a^*	16.22 (1.85) ^A	13.37 (2.45) ^B	12.11 (2.56) ^{BC}	11.56 (2.63) ^C	$P < 0.0001^*$
	b^*	50.87 (2.9) ^A	49.28 (3.84) ^{AB}	48.66 (4.0) ^B	48.86 (4.25) ^B	$P = 0.0223^*$
BF	L^*	79 (2.55) ^A	79.03 (2.53) ^{AB}	82 (2.52) ^{CD}	84.14 (2.33) ^D	$P < 0.0001^*$
	a^*	8.72 (2.12) ^A	6.15 (1.02) ^B	4.82 (1.22) ^{BC}	3.71 (1.17) ^C	$P < 0.0001^*$
	b^*	38.01 (3.3) ^A	32.39 (1.85) ^B	30.22 (1.77) ^B	28.93 (1.79) ^{CD}	$P < 0.0001^*$
RF	L^*	74.16 (3.87) ^A	76.36 (3) ^B	78.76 (4.49) ^C	81.19 (3.88) ^D	$P < 0.0001^*$
	a^*	12.51 (1.96) ^A	10.91 (2.15) ^B	9.77 (2.34) ^{BC}	8.8 (2.38) ^C	$P < 0.0001^*$
BFF	b^*	43.18 (4.09)	41.08 (5.99)	41.03 (5.61)	39.78 (4.42)	$P = 0.0571$
	L^*	79.5 (3.26)	78.5 (2.19)	79.62 (3.11)	79.93 (2.71)	$P = 0.2139$
BFF	a^*	7.66 (1.71) ^A	4.81 (1.76) ^B	4.09 (1.89) ^B	3.57 (1.72) ^C	$P < 0.0001^*$
	b^*	34.16 (3.25)	33.93 (3.56)	33.1 (4.12)	32.09 (3.75)	$P = 0.0840$

The data and statistical analyses obtained for the 22% Carbamide Peroxide subgroup is shown in Table 2. It is possible to verify through the Tukey Test results that for the Bulk-Fill resins (BF and BFF groups) the L^* coordinate did not

result in any statistically significant difference between any of the periods studied. For all other coordinates there was a difference between the initial periods and after 14 days.

Table 2 - Means, standard deviation and ANOVA test results ($p < 5\%$) for repeated measures and Tukey test (superscript) for each of the coordinates (L^* , a^* and b^*) and periods (initial, 1st, 2nd and 3rd sessions bleaching) for the at home Bleaching subgroup (carbamide peroxide 22%)

GROUP	COORDINATE	INITIAL AVERAGE	7 DAYS AVERAGE	14 DAYS AVERAGE	ANOVA
RC	L^*	71.8 (2.0) ^A	74.53 (2.81) ^{AB}	76.38 (2.72) ^B	$P=0.0096^*$
	a^*	13.66 (1.0) ^A	11.33 (1.91) ^B	10.69 (2.37) ^B	$P=0.0042^*$
	b^*	48.6 (2.17) ^A	46.36 (2.73) ^{AB}	44.75 (4.04) ^B	$P=0.0471^*$
BF	L^*	77.85 (1.67)	78.59 (2.02)	79.25 (2.14)	$P=0.2989$
	a^*	9.6 (1.25) ^A	5.93 (1.07) ^B	4.43 (0.87) ^C	$P<0.0001^*$
	b^*	38.96 (1.7) ^A	33.2 (1.75) ^B	31.31 (1.28) ^B	$P<0.0001^*$
RF	L^*	77.3 (4.26) ^A	80.07 (3.58) ^B	82.63 (2.92) ^C	$P=0.0002^*$
	a^*	12.0 (1.37) ^A	8.32 (1.87) ^B	6.79 (1.51) ^B	$P<0.0001^*$
	b^*	43.42 (3.0) ^A	38.48 (3.0) ^B	38.19 (3.66) ^B	$P=0.0020^*$
BFF	L^*	77.8 (2.73)	75.92 (2.53)	77.56 (3.13)	$P=0.0899$
	a^*	9.18 (2.1) ^A	6.33 (1.4) ^B	5.39 (1.48) ^C	$P<0.0001^*$
	b^*	41.72 (6) ^A	36.16 (3.1) ^{AB}	35.69 (3.36) ^B	$P<0.0001^*$

Table 3 and Figure 3 show the mean and standard deviation values of ΔE (variation of color composition or total color variation) of the CIEL* a^* b^* System in the different study groups.

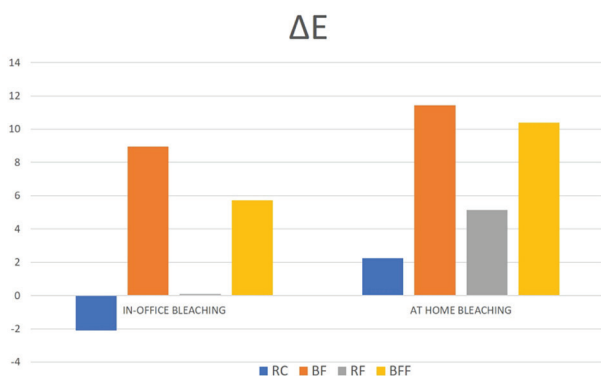


Figure 3 - Mean of ΔE for each study group

Table 3 - Means and standard deviation of the total color variation (ΔE) for the studied groups

IN-OFFICE BLEACHING		AT HOME BLEACHING	
RC	-21 ± 3.22	RC	225 ± 5.15
BF	8.95 ± 6.1	BF	11.45 ± 4.38
RF	0.08 ± 4.0	RF	5.13 ± 5.86
BFF	5.73 ± 3.67	BFF	10.4 ± 2.01

The independent group t-test was applied ($p < 5\%$) to compare the results of ΔE for office bleaching and at home bleaching. Based on the results of the test, it can be concluded that the RF groups ($t = 2.1218$; $p = 0.0483$) and BFF ($t = 3.2545$; $p = 0.0044$) had significantly higher ΔE when subjected to bleaching (carbamide peroxide 22%). The RC groups ($t = 2.0255$, $p = 0.0623$) and BF ($t = 1.0610$, $p = 0.3066$) showed no statistical differences for the ΔE of both bleaching agents tested.

DISCUSSION

With the great aesthetic demand of the XXI century, the use of bleaching agents has become more and more frequent. Dental surgeons can employ two main techniques for the procedure: At home or in-office whitening. Anterior teeth often present aesthetic restorations of composite resin, which are subjected to the action of gel during the bleaching procedure.

The bleaching gels most used in dental practice are hydrogen peroxide and carbamide peroxide in different concentrations. It is evident that the action of the bleaching gels extends not only to the tooth structure, but also to the composite resin. Several studies have sought to correlate these effects, and some of them prove that these gels are able to whiten not only the dental structure, but also the restorative material [13,14].

In this study, the protocols used for both bleaching agents were followed according to the package instructions provided by the manufacturers, in order to mimic as closely as possible what occurs when applied in the oral

environment. In this study, it was decided to measure the colors after staining with soluble coffee [15]. The use of soluble coffee causes formation of spots by absorption and adsorption, and the resistance to its removal from the resin matrix has been shown to be higher when compared to other dyes such as tea or wine [14].

In 1961, Munsell created a visual model that functions as an orbit or sphere with the entire luminous spectrum having a vertical axis that extends from white to black and horizontally progresses from neutral gray to full saturation. The three dimensions were named as follows: hue, luminosity and saturation. Hue is the quality by which we distinguish a color (yellow, red, blue or green). Luminosity is the quality of how we distinguish a light color from a dark color, corresponding to the amount of white or black in the hue, and Saturation refers to the amount of pigment in a color [16].

These color dimensions are widely used when assessing the degree of tooth whitening and which of the dimensions was most influenced during the procedure [17]. To accurately measure colors, the CIEL* a* b* value system [18] can be used. Its major advantage as a tool for representing and characterizing color is its uniformity in color values on the three axes that are distributed with respect to human color perception [19].

In this study, considering the coordinates CIEL* a* b*, only the subgroup subjected to bleaching with hydrogen peroxide showed no significant differences for the L* coordinate (black to white) in the BFF group and for the coordinate b* (+ yellow to blue) for both the low viscosity (RF and BFF) groups. For the 22% Carbamide Peroxide subgroup, there was no difference for the L* coordinate in both Bulk-fill groups (BF and BFF). The non-significant results for the L* coordinate suggest that the luminosity of Bulk Fill resins (except BF - hydrogen peroxide group) is not altered by the action of the bleaching agents used, that is, whitening does not make these resins whiter.

A study by Alharbi et al., 2018, verifying

the action of hydrogen peroxide at 40% (two 30-min applications) on the surface of Methacrylate resins (Filtek Supreme), TCD / UDMA (Venus Diamond) and Silorano (Filtek Silorane) stained with coffee had a $\Delta E > 3.3$ for all, so they considered the amount of stain removal clinically acceptable. Nevertheless, the results show clear differences between the compositions [14].

In this study, for the total variation of the ΔE color, the largest mean variations for both bleaching agents were related to the BF groups, followed by the BFF groups. Color variations visually perceptible to the human eye are those whose $\Delta E > 3.0$ [20,21]. Thus, in this study the visually perceptible color changes occurred in the BF and BFF groups in the Hydrogen Peroxide subgroup and for the BF, RF and BFF groups in the Carbamide Peroxide subgroup.

To verify if there were statistical differences between the types of resin tested and the two types of bleaching, the t test ($p < 5\%$) was applied, and the results showed that the 22% carbamide peroxide presented ΔE statistically superior to the hydrogen peroxide for the groups RF and BFF, both referring to the flow resins. These results differ from the studies by Alharbi et al., 2018 and Canay and Cehreli, 2003, in which the greatest color variations occurred in the groups submitted to hydrogen peroxide bleaching [13,14]. One of the reasons for the difference in results may be related to the application protocol of bleaching gels.

Composite resins have an inorganic portion associated with an organic matrix that vary according to the proposal and the trademark. The organic fraction is mostly associated with the absorption of pigments and chemical changes, which justifies the lower color stability when compared, for example, to ceramic materials [22]. Thus, the composition of the organic matrix of the resin, as well as the amount of inorganic filler, degree of polymerization and water affinity are factors that directly interfere with the absorption of pigments.

Monomers, initiators, stabilizers, additives and pigments are part of the organic matrix of

the composite resins [23]. Bis-GMA (Bisphenol A, Glycidyl Methacrylate) and UDMA (urethane dimethacrylate) have a high molecular weight and have a highly viscous consistency, so they need to be added to other components for the development of a softer and more manipulative composite resin. TEGDMA (Triethylene glycol dimethacrylate) and EGDMA have low molecular weight, however, they both undergo a higher contraction of polymerization [24].

Resins rich in Bis-GMA have pendant hydroxyl groups, leading to a characteristic more susceptible to water absorption. Thus, Bis-GMA-rich resins are also more susceptible to bleaching and easy bleaching action, resulting in greater color variation [25,26].

Another variable to be considered is the degree of conversion of the composite resins. The composition is completely related to the conversion degree of the resins and the incomplete polymerization of the material raises the level of residual (co)monomers [23]. These (co)monomers are cytotoxic and may cause allergies, in addition to impairing the properties of the material, such as color stability and hardness [27,28].

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EDMAB (ethyl 4-dimethylaminobenzoate), a tertiary amine which functions as a co-initiator of the polymerization reaction, is generally associated with camphorquinone to achieve a high degree of conversion. The unreacted camphorquinone during the polymerization process has a strong yellow coloration, which makes the resins that have it yellower than the others [30]. In this study, the coordinate b^* , referring to the yellow color, presented

significant bleaching for all composite resins evaluated, regardless of the presence of EDMAB in its composition.

The limitations of this study revealed that there is an interaction between the dental bleaching agent and the structure of the composite resins, once whitening occurred. Further studies can be developed to verify its action on the surface of this material and regarding further possibilities for removing stains from aesthetic restorations with adequate morphology and replacement not indicated.

CONCLUSIONS

The results of this study showed that, independently of the amount of load, Bulk Fill resins do not guarantee greater color stability than the other composite resins tested, including conventional flow resin, which presents higher organic content. In addition, the conventional composite resin showed lower color variation (ΔE) among all of those evaluated.

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