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Original Article

Effect of Grape Derived Beverages in Colour Stability of Composite Resin Submitted to Different Finishing and Polishing Methods

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Abstract

Objective: To evaluate the influence of three methods of finishing and polishing on color stability of a microhybrid composite immersed in different beverages for 7, 15 and 30 days. **Material and Methods:** 90 samples were prepared and divided into three groups according to surface treatments (polyester matrix, aluminum oxide disc, sandpaper). The samples were divided for each group (n = 6) and immersed in one of the beverages: distilled water, red and white wine, red and white artificial grape juice. Pictures were taken at four time points: 0, 7, 15 and 30 days after contact with the dye. Color measurement was performed by computerized image analysis. La*b* values were obtained and color change (ΔE) was calculated. **Results:** Comparing beverages, red wine (ΔE =22.11±4.26) and red artificial grape juice (ΔE=8.24±1.70) showed greater color change in polyester matrix group, and finishing with aluminum oxide disc (ΔE=10.73±2.10) significantly prevent color change in red wine group. **Conclusion:** Aluminum oxide discs are the best option to minimize color changes in resin. White drinks are alternatives to color stability of composite resin. In the study time, composite resin demonstrated progressive discoloration when immersed in red wine and red juice. On the other hand, samples submitted to white beverages showed higher color stability.

Keywords: Beverages; Composite Resins; Dental Polishing; Pigmentation.

Introduction

The aesthetic has occupied prominent place in dentistry and the material of choice for this purpose is composite resin, which besides giving a good aesthetic performance also allows restoring to a proper function of the teeth. Being a low-cost material, it is easy to handle and allows an acceptable result when clinical protocols are well conducted. In addition to replacing amalgam in posterior teeth [1], composite resin is also chosen to direct restorations of anterior teeth, giving to dental element natural polychromatism [2]. Among the reasons that lead to restoration replacements, one may find secondary cavities and discoloration of the material [3]. Patients treated at the *Araçatuba Dental School* reported that the aesthetic factor is the main reason for substitution of composite restorations [4].

Color stability is a subject widely researched and there is a variety of studies showing that drinks such as red wine, cola, juices, teas and coffees are directly related to the surface staining of composite resins [5-8]. Beverages such as red wine and red grape juice have a large amount of pigment composition, including anthocyanins, which are part of the class of flavonoids, phenolic compounds distributed in the vegetable group. The color stability is directly influenced by the pH and the interaction of this pigment with other phenolic compounds such as tannins [9].

Intrinsic and extrinsic factors influence the color stability of the restorative material. Among these factors are intrinsic discoloration of material itself, alteration of resinous matrix, as well as the characteristics of inorganic matrix, such as shape, size and quantity [10]. Within extrinsic factors it includes the patient's habits, where consumption of beverages and food colorants are inserted, resulting in absorption of pigments that alters the color of the material [7]. Other factors such as technique used by the operator, different methods of finishing and polishing [11] and time at which these methods are performed influence the coloring of the material [12]. In order to provide color stability in composite resin restorations, finishing and polishing procedures are performed to obtain a smoother surface and to remove the unpolymerized resin layer. It is understood by finishing the process of removal of irregularities, in order to improve the anatomical contours, promoting regularity to the surface of the restoration. Polishing is defined as the attempt to reduce the surface roughness, promoting smoothness and shine to the surface [13]. Often, finishing and polishing are obtained by a multi-step process [14].

There are several specific methods to quantify color change in composite resins, such as spectrophotometers, colorimeters and digital image analysis techniques [15]. These various mathematical forms attribute numbers to the color of the analyzed material and convert these numbers into three-dimensional coordinates [16], allowing it to be quantified and its variation to be precisely measured. The records are obtained from the three-dimensional coordinates of La*b* system, which uses a three-axis evaluation parameter, developed by the International Commission on Illumination (ICI). In the "L" axis, color is related to brightness of the object, with values from 0 (black) to 10 (white). The axis a* and b* represent chromaticity coordinates of the color, with values of a* representing the amount of red (positive) and green (negative), while the b* axis represents the amount of yellow (positive) and blue (negative). Thus it is possible to conduct a numerical comparison between two objects, decreasing the likelihood of mistakes [16].

Computerized image analysis has been used in many studies assessing color change, where Adobe Photoshop (Adobe Systems Inc., San Jose, California, United States) is a tool to quantify the values [17-20]. In 2006, digital images were used to compare coffee, tea and red wine staining on composite resins [21]. In 2010, an experiment was conducted using color shade guides and the results validated digital images as a protocol for composite resin color evaluation [22]. In the following year, described a practical and fast method to analyze color data by using a digital camera to obtain images for later color change analysis of composite resin [20].

Studies testing the color change of composite resins by red wine [23] and red grape juice [24] were found in the literature, but there are no reports comparing each other. There are no scientific reports that relate white juices and white wines with composite resin color change. This study aims to evaluate the influence of three methods of finishing and polishing on the color stability of a microhybrid composite resin immersed in red and white wine, red and white artificial grape juice, for 7, 15 and 30 days.

Material and Methods

Sample Preparation

90 samples were made with Fill Magic NT Premiun microhybrid composite resin, A2 color shade (Vigodent Coltene, Rio de Janeiro, RJ, Brazil), using a 4mm diameter and 4mm thick steel matrix. Two trained researchers carried out the sample preparation. The composite resin increments were inserted in two layers into the steel matrix, (Pepasil Ind. Com Ltd., Jaboatão, PE, Brazil) and each layer was photopolymerized for 20 seconds according to the manufacturer recommendations, using a 1.200 mW/cm^2 curing light unit Radii (SDI Ind e Com., São Paulo, SP, Brazil). Before curing the last layer, a polyester matrix was placed on the top and hand-pressed for five seconds with a metal plate. After specimens' preparation, they were stored for 24 hours in distilled water [14,25]. Figure1 illustrates the preparation of samples.

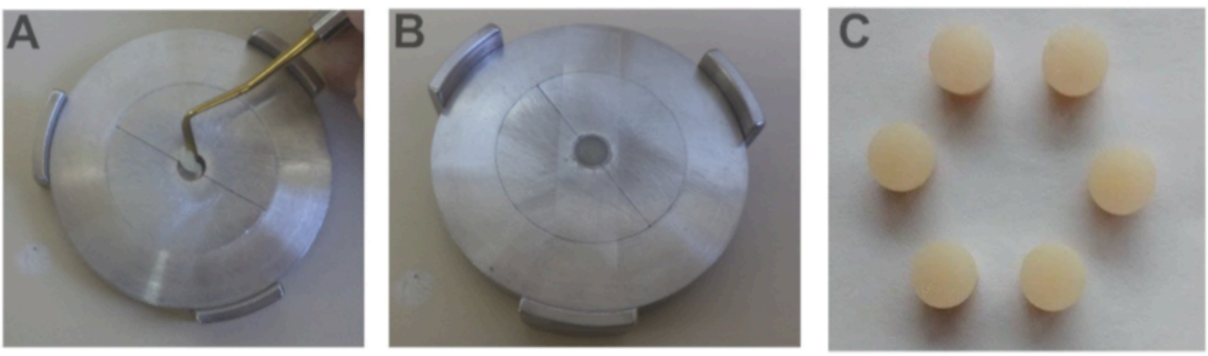

Figure 1. A - Sample preparation. Insertion of composite resin in the steel matrix; B - polyester matrix on the last layer before curing; C - prepared samples.

Surface Treatment

One of the variables tested in this study was "finishing and polishing". Samples were randomly divided into three groups according to the surface treatment, and a code for each group provided a blind-test. The description of groups can be viewed in Table 1.

Table 1. Distribution of groups according to material and technique used.

Groups	Polishing Material	Technique
Matrix Group	Polyester matrix strip	Direct contact with the sample surface
Disk Group	Diamond Disks Pro®	Sequential use of discs (rough, medium, fine and extra-fine) for 15 seconds each. Use at low speed in a circular motion
Sandpaper Group	Watery Sandpaper G 100	Manual operation for 30 seconds in a single direction

Staining Solutions

Another variable tested in the study was "staining solution". Five different solutions were used in this study: red wine (Jota Pe, Farroupilha, RS, Brazil), white wine (Jota Pe, Farroupilha, RS, Brazil), red grape juice (Jota Pe, Farroupilha, RS, Brazil), white grape juice (Jota Pe, Farroupilha, RS, Brazil) and manipulated distilled water (Sealife Manipulation Pharmacy, Torres, RS, Brazil).

After the finishing and polishing procedures, samples of the three groups (n=30) were divided into five subgroups (n=6), according to the staining solutions in which each sample was immersed. The specimens remained immersed in the subgroup-selected staining solutions, inside black round tubs, protected from free light. Solutions were changed every day for 30 days. In each solution exchange, samples were removed, dried with absorbent paper and re-immersed in a fresh solution.

Color Measurement

Color measurement of sample surface was performed by computerized image analysis. Five digital pictures were taken for each group within a darkroom using a Canon digital camera DS 126151 (Canon Inc., Ota, Tokyo, Japan) ISO I600, F 1-100 F 16, lens macro without flash, illuminated by four fluorescent lamps of 15 watts located laterally. The camera was fixed on a holder so that the lens remained at a distance of 20cm from the samples.

Before each photo, the samples were cleaned with distilled water and dried with paper towels. The images were obtained in four stages, in order to access the variable "immersing periods": before submitting samples to coloring solutions (baseline = T0), seven days later (T1), 15 days (T2) and 30 days (T3). The choice of one among the five images taken of each group of samples, to be used for statistical analysis, was based on the luminance values shown by rubber dam. One central portion of the rubber dam was selected (15mm x 15mm) and values of La*b* were obtained and processed, and the images that presented values with no significant difference were selected. This choice aims to discard photos in which color change is detected due to light variation between photos, once the same rubber dam must show no difference from one photo to another. This step worked as a control to the light variable.

The images were stored in JPEG format and, with the help of Adobe Photoshop CS3 software (Adobe Systems Inc., San Jose, California, United States), surface color variation of the samples was measured. For selection of the samples, it was used "QuickSelection" software tool. The system measures each pixel of the selected image and assigns a final numeric value to RGB (Red, Green and Blue).

Values of RGB were then converted into CIE La*b* using the color conversion program Color Slide Rule (Axiphos GmbH, Lörrach, Germany) [26,27]. The color change (ΔE) was calculated using La*b* values of each sample before (T0) and after the immersion period (T1, T2 and T3), using the formula:

$$\Delta E = [(L0-L1)^2+(a^*0-a^*1)^2+(b^*1-b^*0)^2]^{1/2}.$$

Statistical Analysis

The statistical software SPSS 17.0 (SPSS Inc., Chicago, IL, USA) was used to evaluate the effects of variables "finishing and polishing", "staining solution" and "immersing periods" in the disclosure color change. Normality was assessed using Kolmogorov-Smirnov test and Shapiro-Wilk test. Homogeneity of variances was assessed by Levene´s test. The analysis of non-parametric data used the Kruskal-Wallis test, with statistically significant difference considered when $p \leq 0.05$.

Results

According to Kruskal-Wallis test, the interaction among methods of finishing and polishing, staining solutions and immersing periods has statistically significant effect on the color change of the composite resin ($p \leq 0.05$). The mean and standard deviation of color variation (ΔE) are displayed in Tables 2 and 3, as well as the significant differences among the groups.

Table 2. Mean and standard deviation of composite color change (ΔE) according to "finishing and polishing", "staining solution" and "immersing periods" variables.

Groups	Composite Color Change (ΔE)		
Water			
Polishing Methods	**ΔE T1**	**ΔE T2**	**ΔE T3**
Matrix	3.01 (0.35) Aa	2.64 (0.47) Aa	2.54 (0.47) Aa
Disk	2.08 (0.83) Ba	1.25 (1.02) Ba	1.25 (1.01) Ba
Sandpaper	2.29 (0.36) ABa	0.96 (0.59) Bb	0.65 (0.44) Bb
Red Wine			
Polishing Methods	**ΔE T1**	**ΔE T2**	**ΔE T3**
Matrix	14.45 (3.74) Ab	17.34 (4.03) Aab	22.11 (4.26) Aa
Disk	5.23 (1.73) Bb	8.19 (1.65) Ba	10.73 (2.10) Ba
Sandpaper	5.15 (0.91) Bc	8.55 (0.77) Bb	10.57 (0.94) Ba
Red Grape Juice			
Polishing Methods	**ΔE T1**	**ΔE T2**	**ΔE T3**
Matrix	5.81 (1.68) Bab	5.09 (1.74) Bb	8.24 (1.70) Ba
Disk	6.72 (1.00) Ba	11.13 (7.73) ABa	8.21 (0.87) Ba
Sandpaper	11.90 (0.87) Ab	13.17 (0.97) Ab	15.61 (1.76) Aa

White Wine			
Polishing Methods	**ΔE T1**	**ΔE T2**	**ΔE T3**
Matrix	3.22 (0.16) ^{Aa}	2.55 (0.47) ^{Ab}	2.40 (0.48) ^{Ab}
Disk	2.48 (0.18) ^{Ba}	1.16 (0.47) ^{Bb}	1.41 (0.57) ^{Bb}
Sandpaper	2.02 (0.31) ^{Ca}	0.85 (0.39) ^{Bb}	0.82 (0.33) ^{Bb}
White Grape Juice			
Polishing Methods	**ΔE T1**	**ΔE T2**	**ΔE T3**
Matrix	1.59 (0.19) ^{Aa}	0.97 (0.45) ^{Bb}	0.90 (0.50) ^{Bb}
Disk	1.38 (0.60) ^{Aa}	0.63 (0.35) ^{Ba}	1.20 (0.94) ^{Ba}
Sandpaper	1.15 (0.52) ^{Ab}	2.99 (0.68) ^{Aa}	3.46 (0.36) ^{Aa}

T1 = Period of 7 days; - T2 = 15-day period; - T3 = 30-day period; - Equal lowercase letters indicate that there is no statistical difference within the same line; - Equal capital letters indicate that there is no statistical difference within the same column according to Kruskal-Wallis test ($p \leq 0.05$).

Specimens immersed in distilled water had a wider color range within seven days (T1), and the color change only was significant (p = 0.03) between the matrix groups and disk group. During T2 and T3, the matrix group differed significantly from the disk group (p = 0.01 at both Times) and sandpaper (p = 0.00 in both the Times). The disk group, when compared to the sandpaper group, had no significant difference (p = 0.77 in T2 and p = 0.31 in T3).

Samples submerged in red wine showed high color change rate, particularly in the matrix group. It is noticeable that there was a significant increase in color change when the exposure time cumulated, regardless of the type of polish (ΔET1 <ΔET2 <ΔET3). At all times, the matrix group showed greater change in color and differed significantly from the disk group and the sandpaper group.

Pigment is more adherent to an irregular surface (sandpaper group) because color variation in red juice group showed up progressively in accordance with the increase in exposure time (ΔET1 <ΔET2 <ΔET3). At white wine exposure, a greater color variation occurred in polyester matrix group and, over time, the change in color values decrease no matter the group tested. The sandpaper group showed lower values and its greatest value is in T1 (ΔE = 2.02). By observing T3, once again the matrix group showed greater color change (ΔE = 2.40), which is significantly different from the disk group (p = 0:00) and sandpaper (p = 0:00).

The white grape juice demonstrated similar behavior to red juice in "finishing and polishing" variable, once sandpaper group showed greater color change in a progressive manner over time. Within the sandpaper group, greater color change occurred in the 30-day period (ΔE = 3.46). When comparing sandpaper and disk groups, they showed no statistically significant difference between them in any of times, with greater color change in the matrix group in 7 days (ΔE = 1.59) and less color change in the disk group 15 days (ΔE = 0.63).

Table 3 allows comparing the means among "staining solutions" during the T3 period. It can be said that in both red and white wine groups, the greatest color change presented was in the matrix group. Distilled water, white wine and white juice do not differ significantly in matrix group and disk group. When these same beverages are compared within the sandpaper group, water and white wine does not have significant differences (p = 0.99), but there are significant differences between water and white juice groups (p = 0.00), as well as between white wine and white juice (p = 0.00). Therefore, in matrix group at T3, the color change showed this descending order: red wine> red juice> distilled water> white wine> white juice. In the disk group red wine > red juice> white wine> distilled water> white juice and finally the sandpaper group, red juice> red wine> white juice> white wine> distilled water. It is possible to realize that, considering “finishing and polishing” variable, wines had more effect on color range in the matrix group, while juices had greater influence is the sandpaper group.

Table 3. Mean and standard deviation of composite resin color change (ΔE) in T3* according to “finishing and polishing” and “staining solution” variables.

T3					
Polish	**ΔEWater**	**ΔERed Wine**	**ΔERed Grape Juice**	**ΔEWhite Wine**	**ΔEWhite Grape Juice**
Matrix	2.54 (0.47)c**	22.11 (4.26) a	8.24 (1.70) b	2.40 (0.48) c	0.90 (0.50) c
Disk	1.25 (1.01) c	10.74 (2.10) a	8.22 (0.87) b	1.42 (0.57) c	1.20 (0.94) c
Sandpaper	0.65 (0.44) d	10.58 (0.94) b	15.62 (1.76) a	0.82 (0.33) d	3.46 (0.36) c

*T3 = 30 days immersion period. ** Equal letters indicate that there is no statistical difference within the same line according to Kruskall-Wallis test ($p \leq 0.05$).

Discussion

This study had as drinks of choice wine and grape juice, both red and white, in order to study, as a secondary objective, the alcohol variable, once there are studies testing composite resins color change due to red wine [5,6] without explaining the influence of alcohol in the process. One drawback of *“in vitro”* studies is the difficulty to simulate, in the laboratory, clinical situation. The flash of digital cameras may not distribute the light in all directions, affecting the La*b* values [26], therefore, it was decided not to use camera flash in this study. All pictures were taken inside a darkroom using lightning from fluorescent lamps, according to previous study [20].

Clinically, exposure to staining solutions is not as intense as used in this study, but it did not constitute a bias for data comparison, since all samples were exposed to equal staining protocols. In an attempt to bring the experiment to reality, it was taken into account that World Health Organization (WHO) considers an acceptable level of daily consumption three doses of 120 ml of wine for men and two for women [27]. Since there was no data found on how much time it takes for these daily doses consumption of wine, this study followed data found in the literature [6], which establish that the average time for the consumption of a cup of coffee is 15 minutes. Considering consumers take two cups/day, and the liquid contact oral cavity 30 minutes a day, in 30 days it will be 900 minutes. In this study, 30 days of direct storage in the staining solutions tested will be comparable to 43,200 minutes of clinical exposure, which simulates a 48 months consumption.

In addition to patient dependent factors, such as hygiene and consumption of staining drinks, hydrophilic properties of restorative composite materials lead them to a higher probability of discoloration. In particular, composites with high amounts of TEGDMA-monomers, like those used in this study, may be more susceptible to absorption of water, causing a greater dye penetration, thus causing staining [6]. There are finishing and polishing procedures performed by the dentist, whose objective is to maintain the restoration color stability. In this work we decided to use aluminum oxide discs, because there is evidence that this multiple-step technique is more effective in achieving a smoother surface when compared to single-step techniques, even when microhybrid composites was used [14]. Polyester matrix was included in the experiment once it promotes the largest composite surface smoothness [13], as well as a group called sandpaper, leaving the roughened surface in order to simulate an inappropriate finishing and polishing system.

In 2004, a study analyzed digital images in Adobe Photoshop® to assess the reliability of the color scales and concluded that when photographs are standardized in distance and lightning, as is the case of this study, digital evaluation is a reliable method [19]. In 2005, a different study compared tooth whitening using values obtained by digital images and a spectrophotometer and the results found in two forms of measurement correlated [18]. It was observed equivalency between La*b* values obtained by a spectrophotometer and La*b* values obtained by digital images [26]. The authors obtained RGB values of images using Adobe Photoshop software and converted to La*b* color through a conversion program, as done in this study. Adobe Photoshop software provides La*b* values, but L values are ranging from 0 to 256, differing from CIE scale, whose range is from 0 to 100, therefore, it was used the conversion of RGB values, obtained from the software, to La*b* values using a conversion application [26].

In this study, the rough surface obtained in sandpaper group caused a greater staining in red juice drink. This results meets findings in the literature, as there are reports that surface treatment is connected with restorations quality [10], therefore, rough surfaces have a negative effect, facilitating staining [28]. After the immersion periods conducted in this study, it was found that distilled water promoted its greater potential in color change in seven days, this can be explained by the fact that a large part of composite´s water absorption occurs in the first week [29].

The greatest color change found in our results was caused by red wine in the 30-day period, corroborating other findings [23], in which red wine and curry caused more severe composite color changes after four and eight weeks. A beverage containing at least 9% volume of ethanol increases the composite's wear and facilitates the color change by softening the composite resin matrix. Other constituents of wine do not seem to have an effect on composite wear [30]. This may explain that most color change occur in the matrix group, where composite superficial organic layer was not removed by any polishing. It was observed that red wine and juice promoted higher color change values and one concludes that it occurs because of the pigments they have in their composition [9]. White drinks caused minor color change by the absence of these pigments.

A spectrophotometer analysis was performed to assess the stability of resin color in different immersion media, including grape juice. Surface treatment used sandpaper grain 600-1200. The authors concluded that in the first week, the average color change (ΔE) caused by grape juice was 11.2 [24]. This data agrees with the findings in this study, as it was observed that during the same period, in sandpaper group, grape juice promoted a color change of 11.9. This demonstrates that the use of computerized image analysis can be a reliable means for studies on color change, because data obtained from images in this study were similar to data obtained in an independent study with a spectrophotometer.

Multistep finishing and polishing system used in this study played a critical role in decreasing susceptibility to color change of the studied resin. It acted removing the surface layer rich in organic matrix. This result is in accordance to literature [11] about multiple polishing steps reducing composite staining. Samples immersed in wine showed an intense staining when the finishing and polishing was exclusively done by the polyester matrix. This result can be explained by the presence of a uncured resin layer, with a smaller degree of polymerization, leading to liquid absorption, promoting lower color stability [6].

In clinical practice, the results of this experiment suggest that one should not leave a roughened surface, nor use polyester matrix alone. Aluminum oxide discs would be more suitable to minimize color changes in composite, so multiple step finishing and polishing procedures should always be performed. It is important to guide the patient regarding the consumption of drinks free of pigments, so white beverage options are valid for cases with large composite resin restorations.

Conclusion

Upon reaching the end of this study, it is concluded that finishing and polishing with aluminum oxide discs is the best option to minimize color change in composite resins submitted to an intake of wine and juices, both red and white. It notes that white drinks are the best options for patients who have composite resin restorations. Results show that beverage inks cause progressive color change.

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