Comparative Study of Color Stability of Three Composite Materials, Treated by Finishing and Coated Sealing, After Immersion in Different Wholesale

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The present study was conducted to evaluate the effects of common drinks consumed by patients (Coffee, Coca-Cola, Black Tea) on different types of composite restorations, finishing and surface sealing (nanocomposites, nanohybrids, ormocers) regarding color changes. 45 specimens of composite materials (Nanoceramic, Nanocomposite and Nanohybrid) were made and divided into 3 groups G1-control group, G2 - finished in 2 stages, and G3 glaze coated. The LOVIBOND RT 300 portable spectrophotometer was used to determine the color by following the CIELAB scale. The data was analyzed using Mann-Whitney followed by a multiple comparison t test. Significant differences were found between the groups in terms color changes ($p<0.001$). The results showed that for both groups of composites (G2 and G3), irrespective of the beverage they were immersed in, the ΔE values were significantly higher at 7 days compared with the 30 day values.

Keywords: composite; finishing; polishing; spectrophotometry; color changes

Composite resins are the most commonly used aesthetic restorative materials because of their universal use, similar to dental structure in color and mechanical properties, requiring minimal tooth structure removal and ease of use in the dental office [1]. Due to patient expectations for better aesthetics, there has been a demand for the development of restorative materials with excellent aesthetic properties. However, in order to be considered clinically acceptable, the materials should not only provide an initial match of colors, but also maintain the aesthetic aspect throughout the years in the restored tooth. Therefore, coloring ability can be considered an important criterion in choosing a material for use in an aesthetic critical area. Correct choice of the color of a restoration is an important aspect in the aesthetic restoration of the affected tooth, many factors may complicate the choice of the optimal tint such as the cabinet lighting system, the dehydrated teeth are whiter, the color of the doctor's or patient's clothing and the experience of the person records the hue. Choosing the nuance requires knowledge of the physics and physiology of color; therefore, it is also an art and science that requires in-depth knowledge, precise clinical thinking and the dentist's perception [2]. Aesthetic restorative dental treatments have shown that it exerts a positive psychological effect on patients' self-esteem [3]. Color stability is an important parameter for modern resin-based restoration materials. Several factors influence the color stability of contemporary light-activated materials, such as the photoinitiated system, resin matrix, polymerization lamp, and irradiation times [2]. However, the optical properties of dental composite resins change due to polymerization, and the magnitude of change is influenced by the brand and shade of composite resins and the photopolymerization light wavelength [4]. The composition of the composite resin, the structure and the filling characteristics has a direct impact on the color susceptibility and the changes that can be invoked both during the restorative process and after its completion [5]. Color changes of composite resins can be caused by internal or external factors. Inner-induced blemishes are permanent and are related to the polymer quality, the type of filler and its amount, and the synergistic agent added to the photoinitiated system. In the case of photo-polymerizable composite resins, if the photopolymerization time is not observed, unconverted camphor-quinone will cause a discoloration of the yellowish restoration. Moreover, other components of the photoinitiated system, namely tertiary or aliphatic amines, tend to cause yellow or brown coloration under the influence of light or heat [6-9]. The affinity of the composite resin for extrinsic stains is modulated by conversion rate and physicochemical characteristics, with water absorption being of importance. In the oral cavity due to superficial degradation or slight penetration and adsorption of coloring agents to the superficial layer of composite resins, the surface or interior of composite restorations may be discolored. Furthermore, external induced discoloration may be related to surface roughness, surface integrity, finishing and polishing techniques, and surface restoration status [10-12]. The color changes of restorations can be evaluated by visual and instrumental mechanisms. The instruments eliminate the subjective interpretation of visual color comparison, so even slight changes in color can be detected in restorative dental materials using spectrophotometers and colorimeters.

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Purpose of the study the present study was conducted to evaluate the effects of common drinks consumed by patients (Coffee, Coca-Cola, Black Tea) on different types of composite restorations, finishing and surface sealing (nanocomposites, nanohybrids, ormocers) color changes. Color analysis was performed independently of human perception. The hypothesis of this study was that the different immersion media for finished and sealed composite resin specimens had no effect on color stability at different times (7 days or 30 days respectively) for the three studied materials.

Experimental part

Materials and methods

For this study, 45 composite discs with a diameter of 15 mm were made (Ormocer, Nanohybrid, Nanocomposite). The discs were made on a glass plate in a Teflon container (15 mm in diameter). A Mylar strip was placed on the surface of the composite to avoid imperfections during manufacture. All composite specimens were light-cured with the Led lamp (demi plus, Kerr, Danbury, CT US) with a polymerization light of 1100mW / cm2 for 20sec (as indicated by the manufacturer). After photopolymerization, the composite specimens were divided into 3 groups, each containing 15 disks:

-Group 1 (n = 15) specimens that were not finished and polished (control group);

-Group 2 (n = 15) composites finished in two stages - 1. Finishing with special composite finishing (NTi), 2. Sof-lex (3M ESPE).

-Group 3 (n = 15) for which after the photopolymerization of the composite was sealed with sealant (Seal and Shine - Pulpdent, USA) by applying it with the help of a brush and further curing the curing according to the manufacturer's instructions;

Specimens were stored in artificial saliva for 24 hours at a temperature of 37°C prior to the first color measurement.

The LOVIBOND RT 300 portable spectrophotometer was used to determine the color by following the CIELAB (Commission Internationale de l'Eclairage) scale, in which the L* value (values from 0 to 100) is coordinated to measure the luminosity - obscurity of the specimens; the higher the L* is the lighter the specimen. The coordinate of a* (values from -80 to +80) measures the chromaticity on the red-green axis; a positive value of a* indicates red accentuation, while a negative value of a* indicates the intensity of the green. The value of the b* (values from -80 to +80) measures the chromaticity value on the yellow-blue axis; a b* positive value indicates that the specimens are to yellow, while a b* negative value indicates that the specimens are to blue [13-17].

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

in which:

ΔL^* = L* sample - L* etalon

Δa^* = a* sample - and a* etalon

Δb^* = b* sample - b* etalon

where:

- ΔL^* indicates any difference in brightness, and when: $\Delta L^* > 0$ The sample is brighter than the standard; $\Delta L^* < 0$ the sample is darker than the standard;

- Δa^* measures the chromaticity on the red-green axis and Δb^* measures the chromaticity value on the yellow-blue axis: $\Delta a^* > 0$, the sample is redder than the standard; $\Delta a^* < 0$, the sample is greener than the standard;

- Δb^* measures the chromaticity on the yellow-blue axis: $\Delta b^* > 0$, the sample is yellower than the standard; $\Delta b^* < 0$, the sample is bluer than the standard.

The composite discs were placed one at a time in the device on a white sheet of paper to avoid color reflection and falsely positive or false negative values. After spectrophotometry, the specimens were inserted into the artificial saliva of Afnor for 30 days. Each day (for 30 days) the disks were removed from saliva and immersed in 3 beverages (Coffee-Espresso, Coca-Cola and Black Tea) for 10 min at 37°C. Spectrophotometry resumed at 7 days and 30 days. Before performing the measurements, the specimens were washed with distilled water for 30 s and dried with absorbent cloths.

Results and discussions

In the CIELAB system, L is coordinated to measure the brightness - obscurity of the specimens; the higher the L is the lighter the specimen.

Table 1 show the data obtained from the spectrophotometric analysis for the three types of investigated materials and liquids.

The negative values of ΔL^* demonstrate the dark coloring of the finished samples after immersion in coffee, coca-cola and black tea at 7 and 30 days respectively.

Comparison of the composites with each other, depending on the finishing, polishing or surface sealing system at 7 days and 30 days, used the t test in table 2.

Table 1
COLOR CHANGES – ORMOCER, NANOCOMPOSITE AND NANOHYBRID FINISHED AND POLISHED, IN 3 DIFFERENT BEVERAGES, 7 DAYS AND 30 DAYS RESPECTIVELY

Polished Ormocer / coffee immersion	ΔE*	Polished Nanocomposite /coffee immersion	ΔE*	Polished Nanohybrid /coffee immersion	ΔE*
etalon		Etalon		etalon	
7z	5.91	7z	4.91	7z	4.96
30z	3.99	30z	1.89	30z	3.96
Polished Ormocer / Coca-Cola immersion	**ΔE***	**Polished Nanocomposite /Coca-Cola immersion**	**ΔE***	**Polished Nanohybrid /Coca-Cola immersion**	**ΔE***
etalon		Etalon		etalon	
7z	3.97	7z	3.38	7z	3.17
30z	1.55	30z	2.8	30z	3.08
Polished Ormocer / black tea immersion	**ΔE***	**Polished Nanocomposite /black tea immersion**	**ΔE***	**Polished Nanohybrid /black tea immersion**	**ΔE***
etalon		Etalon			
7z	3.25	7z	5.98	3.8	3.8
30z	3.3	30z	1.99	2.39	2.39

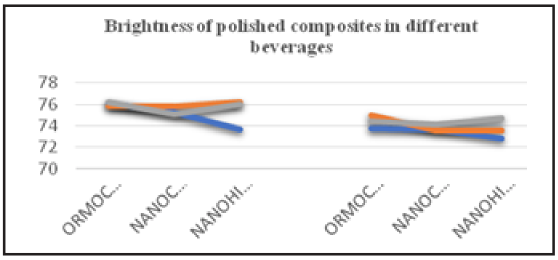

Fig. 1. Evaluating the brightness of finished and polished specimens depending on the composite and in different beverages

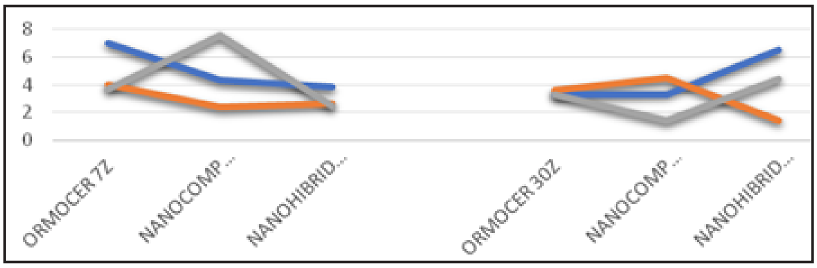

Fig. 2. Evolution of color changes (ΔE*) for sealed composites in different beverages at 7 and 30 days respectively

Table 2
TIME INTERVAL COMPARISONS: 7 - 30 days (G1, G2, G3)

Pair comparison over time: 7 - 30 days		Paired Differences 95% Confidence Interval of the Difference Upper	t	df	Sig. (2-tailed)
Pair 1	O G1 - G1.30 days	.08849	9.862	19	.000
Pair 2	O G2 - G2.30 days	.07093	8.197	19	.000
Pair 3	O G3 - G3.30 days	.11259	12.553	19	.000
Pair 4	NC G1 - G1.30 days	.11529	9.801	19	.000
Pair 5	NC G2 - G2.30 days	.09685	13.093	19	.000
Pair 6	NC G 3 - G3.30 days	.17039	10.468	19	.000
Pair 7	NH G1 - G1.30 days	.10405	14.591	19	.000
Pair 8	NH G2 - G2.30 days	.09287	9.779	19	.000
Pair 9	NH G3 - G3.30 days	.15260	22.282	19	.000

By comparing the composite specimens of the 3 groups studied, it is observed in all pairs of p = 0.0001 <0.05, which is statistically significant.

In this study, a spectrophotometer was chosen that measures the precise sections of the visible light spectrum and is based on the specimen body reflection through specific wavelengths. This wavelength measurement method reports the specimen reflection values in ÄE* units. E* values can be used to represent the color changes presented by the restoration materials after a specific treatment or a period of time [6]. According to Lee et al. [7], ΔE* <1 refers to color changes that are not detected by the human eye; ΔE* <3.3 - represent clinically acceptable color changes; and - ΔE * > 3.3 - color changes unacceptably clinically, leading to the need to replace the restoration due to poor aesthetics. In this study, comparing the composites of the two study groups (G2 and G3), it is observed that the most important changes of ÄE occur in G2 at 7 days, and in G3 at 30 days. Changing the color of composite resins after contact with various colored environments is a common problem for dental practitioners and patients, causing financial and time costs through the need to replace restorations [8]. Patients want aesthetically integrated aesthetic restorations in the oral environment not only immediately after application but also over a period of several years of functioning in the oral cavity. Changes in color can occur both from intrinsic causes and from extrinsic causes. The intrinsic causes are the affinity of the external pigment resins, depending on the physico-chemical characteristics (water absorption) and the conversion rate. External induced color changes are related to surface roughness, surface integrity and finishing technique [9]. A series of physicochemical processes are involved in the degradation of the structure and functions of the organic matrix (plasticizing, soaking, expansion, oxidation and hydrolysis) [5]. Although the studies on the effect of beverages on chromatic stability of composite resin restorations are numerous, their results are different. Thus, while Turkr & col. [10] finds that the most significant color changes of composite resin restorations are due to tea, followed by red wine and orange juice, Ertas & col. [11] demonstrates that the fastest color changes are due to immersion in red wine. This research group finds that the following fluids cause color changes of the composite resins (in ascending order): water, cola, tea, coffee, red wine. These two studies demonstrate that red wine, coffee and tea are the liquids that cause the most significant color changes of composite resin restorations [10-12]. The time of holding liquids in the oral cavity is as important as the type of fluid. In the case of distilled water, color changes, even less important, are due to the water absorption and the release of compounds from the chemical structure of the composite resins. The water absorption level is a function of the organic resin content and the resistance of the interface between organic resin and inorganic fillers [8]. Higher levels of water absorption lead to volume expansion and plasticization of the composite resin, followed by the appearance of microfiche's in the restoration mass and the spaces between the fillers and the organic resin associated with color penetration and pigmentation [11]. Color changes occur more rapidly and are of higher intensity for composite materials having the structure of Bis-GMA organic resin, which has a hydrophilic capacity superior to UDMA organic resin, the latter being more resistant to color changes. Also, high-diameter composite resins (macrofill vs. nanofiller, micro-hybrid vs. nanohybrid) are more susceptible to color changes associated with aging phenomena [18, 19]. For restorations with rough surfaces due to inadequate finishing and polishing techniques, an acceleration of color changes is observed. In the study presented in this chapter, the results support the literature data on color changes of nanofiller composite resin under the action of beverages such as coffee, red wine and tea [12-19]. Tunc [12] found in a study evaluating the color changes in a micro-hybrid composite resin that the most significant color changes were caused by cola beverages, followed by grape juice and chocolate milk. The weakest color changes, clinically perceptible, were caused by immersion in distilled water. Omata [18], comparing the color changes induced at the surface of composite resins, finds that distilled water does not produce clinically perceptible color changes, but artificial saliva induces small but clinically perceptible color changes. Ruyter demonstrated that Coca Cola drink has the lowest pH and that it could damage the surface integrity of composite resin materials. It does not produce as much fading as coffee or tea, possibly due to the lack of yellow dye [19-25].

Conclusions

This study demonstrated that using composite sealant on composite resins restoration increases the possibility of color changing for composite resins after contacting various colored environments. Regardless the finishing or coating system used, nanocomposite and nanoceramic have significantly higher qualities than nanohybrid.

Nanocomposite material presented the best color stability both at 7 and after 30 days measurements, for polished group, which makes us conclude that nanotechnology has had a beneficial effect on integrating stable chemical particles into the matrix of composite materials, contributing to the low wear rate of the materials.

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