Original article

Effect of Staining and Bleaching on Color Change of Resin Composite Restorative Materials

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ABSTRACT

Aims: To evaluate the color change of three resin composites (nanohybrid; Filtek Z250XT, microhybrid, DenFil, and nanoceram; Zenit) after exposure to tea, coffee, artificial saliva, and bleaching procedure.

Materials and Methods: A total of 162 disc-shaped specimens (12.2mm diameter, and 2.2mm thickness) from the three resin composites were prepared in a silicon mold, then divided into 3 groups according to the type of resin composite. Each group was subdivided into three experimental groups (n=18), and immersed into staining solutions; tea, coffee, and artificial saliva for 3h/day over 28 days. A bleaching agent (Opalescence 20 home bleach) was applied to previously stained specimens for 3h/day over 14 days. The color measurement for each specimen was performed according to CIE L*a*b* system using a spectrophotometer on three occasions: i) at baseline, ii) after staining, and iii) after bleaching. The color differences delta E (ΔE) between the three measurements were calculated and the obtained data was statistically analyzed.

Results: The three composites showed significant color change after immersion in tea, and coffee solutions ($P<0.05$), and after the bleaching ($P<0.05$). DenFil showed the most color change followed by Z250XT. Zenit was the least affected by staining solutions. Tea solution caused more color change than the coffee solution. Artificial saliva showed insignificant color change for all groups ($P=0.07$).

Conclusions: Exposure to drinks with staining ability such as tea and coffee can significantly affect the color stability of the tested composites. The bleaching agent was effective in removing the stains and restoring the color of all composites near or at baseline color.

Keywords: *color change, resin composite, tea, coffee, staining solution, bleaching.*

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INTRODUCTION

Resin composites are very popular and widely used restorative materials for anterior and posterior teeth, due to their esthetics and improved physical and mechanical properties.[1] However color stability which is the ability of the material to maintain its original color remains the main esthetic problem.[2] These restorative materials are susceptible to various degrees of discoloration due to continued exposure and interaction with colorants ingredients in certain foods and beverages in the oral environment.[3] This discoloration causes patient discomfort, dissatisfaction, and may need replacement of the restoration.[4]

The discoloration is also affected by accumulation of plaque, and oral hygiene status, daily dietary intake of food and beverages with staining ability such as tea, coffee, cola, coloring mouth rinses, and smoking habits.[5, 6] In this context, staining agents can penetrate the superficial layer of resin composite causing degradation and softening of the resin matrix where its ability to resist stain is reduced,[7] and consequently lead to discoloration of the resin composite.[8] In addition, several factors can affect the color and staining susceptibility of the resin composite leading to color change such as visible light, ultra-violet irradiation, thermal changes, vigorous finishing and polishing procedures, humidity, curing time, curing mode, aging conditions, and composition of the materials such as matrix and filler type and size.[8-14]

Because of the discoloration problem of the resin composite restorations, patients are looking for a bleaching procedure to remove the stains and improve the esthetic demand. Thus, various bleaching products are available in the market and become very popular and well accepted by the patients.[15] Several studies were conducted to investigate the effects of those bleaching materials once they come in contact with the esthetic restorative materials, such as their influences on the physical and optical properties of the resin composite restorative materials.[2, 15-20]

It is important to investigate the color stability of resin composite restorative materials and the efficacy and performance of bleaching materials.[15] This is to assist dental clinicians to choose the proper materials that go with the diet habits of the patients, and can also help to predict the success rate of the restorations.[17] It can also allow the clinician to educate and advise the patient about the effects of specific chromogenic components in the diet such as tea, coffee, and cola on the color change of the resin composites.[18] This study was performed to evaluate the color change of three resin composite restorative materials (nanohybrid, microhybrid, and nanoceram) after exposure to three staining solutions; tea, coffee, artificial saliva, and bleaching procedure.

MATERIALS AND METHODS

Detailed description and composition of the resin composites materials evaluated in this in-vitro study are listed in Table 1. Research approval has been obtained by the Committee on Ethics in Research, faculty of dentistry, University of Benghazi (Certificate Reference No. 094).

Specimen preparation

A total number of 162 disc-shaped specimens were prepared from three commercially available resin composites shade A2 namely: a nanohybrid (Filtek™ Z250 XT), a microhybrid (DenFil™), and a nanoceram (Zenit) (Table1). The specimens were divided into three groups (n=54) depending on the type of composite material; C1=Z250, C2=DenFill, C3=Zenit. For each brand of resin composites; the specimens were prepared by condensing the resin composite material into a silicone mold with circular holes measured 12.2 mm in diameter and 2.2 mm in thickness. A celluloid strip was placed over the material, and then a glass slide was pressed against the upper surface to extrude excess material and to create a flat surface.

All specimens were polymerized by a light-curing unit (Radii plus LED cordless curing light) with the same intensity and light-curing mode to standardize the specimen preparation. The specimens were placed in jars of distilled water for 24 hours at room temperature in complete darkness to allow complete polymerization. After 24 hours of water stage, the color of all specimens was measured using a Spectrophotometer (UV mini-1240 UV-VIS Spectrophotometer SHIMADZU, Germany). This measurement is considered as base-line color measurements for each type of resin composites before the staining procedure. Each group of a composite of 54 specimens was subdivided into 3 experimental groups (n=18)[15] according to the staining solution into which the specimens were immersed in as following: Group1 (Gp1): artificial saliva (saliva simulating solution) and consider as a control group, group 2 (Gp2) in Tea solution, and group 3 (Gp3) Coffee solution.

Staining procedure

Tea solution was prepared by dipping two bags of (Lipton red tea) in 300 ml of boiled water for five minutes according to manufacturer recommendation (150 ml for each bag).[2] The teabags were removed and the solution is allowed to cool at room temperature, then sub-divided to 100 ml at each of the three jars.

Coffee solution: Two bags of Nescafé plain coffee were stirred in 300 ml of hot water until completely dissolved according to the manufacturer's recommendations (150 ml for each bag)[2]. The prepared coffee solution is allowed to cool at room temperature and then subdivided into three portions of 100 ml each in three jars.

The specimens were placed in Tea (T) or Coffee (F) solution according to the intended sub-groups for three hours daily,[2, 15] and then were kept in artificial saliva for the rest of day.[14] The staining solutions were freshly prepared each day with the same method throughout the testing period (28 days).[24] The third group of specimens was kept at artificial saliva throughout the experiment period in jars completely covered to prevent evaporation of the solutions. Artificial saliva solutions were changed daily. All specimens were rinsed with tap water, plot dry, and kept into dry containers for color measurement by spectrophotometer after staining.[25]

Bleaching Procedure

Bleaching agent Opalescence 20 home bleach (20% carbamide peroxide), (Table 1) was painted on the top surface of the previously stained composite specimens according to the manufacturer's instructions and remains for 3 hours per day for 14 days.[2, 14, 15, 17] After bleaching; the specimens were rinsed with tap water for 1 minute to remove the bleaching agent, plot dry, and stored in artificial saliva.[25] All specimens were rinsed by tap water, plot dry, and kept in dry containers for color measurement after bleaching procedures. All the experiments were prepared at the same conditions of temperature, illumination, and relative humidity.[14]

Table 1: Detailed description and composition of the materials used in the study

Product name	Manufacturer	Composition [(a)]	Lot number	Expire date
Nanohybrid Composite, Filtek™ Z250 XT	3M™ ESPE™, USA[1]	Bis-GMA, UDMA, Bis-EMA, PEGMA, TEGDMA. Zirconia/silica 20 nm. Filler loading: 82% vol.	N915906 CE 0123	2021-08-28
Microhybrid Composite, DenFil[TE]	VERICOM LTD, Korea[2]	Bis-GMA, TEGDMA. Barium alumino-silicate particles. Fumed silica 0.04µm. Filler loading: 80% vol.	DF8614A2 CE 0120	2021-06-06
Nanoceram Composite, Zenit	PD President Dental, Germany[3]	UDMA, Butanedediol DMA, Bis-GMA. Pyrogenic silica 12nm Glass filler 0.7µm. Agglomerated nanoparticles 0.6µm. Filler loading: 70% vol.	2017006943 CE 1984	2021-04
Opalescence 20 home bleach	Ultradent, USA	20% Carbamide peroxide, Potassium nitrate, 0.11% fluoride ions Mint flavor	N915907	2021-06-07
Staining solutions:				
Artificial saliva	Gulf Inject LLC-Dubai UA	Sodium chloride 0.86gm, potassium chloride 30gm, and calcium chloride 0.33gm in each 100ml.		
Coffee, Nescafe`	Nestle\ Swiss	Instant Plain Coffee without sugar		
Tea, Lipton	Unilever\United Kingdom	Black Tea		

[(a)] **According to manufacturers' data: Bis-GMA**: bisphenol-A-glycidyl methacrylate; **UDMA**: urethane dimethacrylate; Bis-**EMA**: ethoxylated Bisphenol-A- glycidyl methacrylate; **TEGDMA**: Triethylene glycol dimethacrylate; **PEGMA**: polyethylene-A-glycidyl methacrylate; **DMA**: dimethacrylate.

Assessment of the color change (Color measurements):

A colorimetric evaluation according to the CIE L*a*b* system[26] was performed to record the color change of the specimens using a spectrophotometer (UV mini-1240 UV-VIS Spectrophotometer SHIMADZU, Germany),[15, 24, 25] against a black background to simulate the absence of light in the mouth[17]. The spectrophotometer was calibrated regularly before starting the actual color measurement. The specimen should be clean and dry before being positioned at the determined place in the device.

All specimens were chromatically measured three times[24] as follows: (1) at the baseline before staining procedures (m_0), (2) after 28 days of staining period (m_1), and (3) after bleaching procedure (m_2). Where m=time. The spectrophotometric evaluation was done at the Optics laboratory in the Physics department of the Faculty of Science, University of Benghazi. Values of color difference (ΔE) were obtained according to the equation proposed by the Commission International de l'Eclairage CIE L*a*b*: $\mathbf{\Delta E^*_{ab} = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1\backslash 2}}$ where, L* = variation of luminosity, quantified with a scale ranging from 0 to 100. The measurements of *a** and *b** corresponded to chromaticity coordinates, where, a*=green/red axis, and b*=yellow/blue axis.[27] The ΔE values at different intervals to determine the color change of the resin composite using the equations: [14, 15, 18, 25]

$\Delta E_0 = [(\Delta L_0)^2+(\Delta a_0)^2+(\Delta b_0)^2]^{1\backslash 2}$ color difference at baseline.

$\Delta E_1 = [(\Delta L_1)^2+(\Delta a_1)^2+(\Delta b_1)^2]^{1\backslash 2}$ color difference after immersion in staining solution.

$\Delta E_2 = [(\Delta L_2)^2+(\Delta a_2)^2+(\Delta b_2)^2]^{1\backslash 2}$ color difference after bleaching process.

$\Delta E_3 = [(\Delta L_1-\Delta L_0)^2+(\Delta a_1-\Delta a_0)^2+(\Delta b_1-\Delta b_0)^2]^{1\backslash 2}$ color difference between baseline and stained composite.

$\Delta E_4 = [(\Delta L_2-\Delta L_0)^2+(\Delta a_2-\Delta a_0)^2+(\Delta b_2-\Delta b_0)^2]^{1\backslash 2}$ color difference between baseline and bleached composite.

Statistical analysis

Statistical analysis was performed using SPSS software version 20. Means and standard deviations were attained for each group. Differences in color change (ΔE) by the immersion protocols were calculated at baseline ΔE_0, after staining ΔE_1, and after bleaching ΔE_2. One-way analysis of variance test (ANOVA) was used to evaluate the effects of immersion solutions on color change after staining (ΔE_3 between baseline and stained specimens). Two-way ANOVA was performed to compare the effect of immersion solutions and bleaching agent on color change after bleaching (ΔE_4 between baseline and bleaching). Tukey`s Post hoc test was used for pair-wise comparisons between the means when ANOVA tests were significant. Statistical significance was set in advance at the 95% probability level (Probability value ≤ 0.05).

RESULTS

Means and ±standard deviations of color difference delta E (ΔE) values for the three resin composites into each immersion solution, and after bleaching are summarised in Table 2.

The three types of resin composite specimens are changed in color after immersion in coffee and tea solutions for three hours per day for 28 days. Tea solution had more ability to stain the three brands of resin composites than the coffee solution. However, the color is slightly changed by immersion into artificial saliva for the same period of time (Table 2).

Table 2: Means and ±Standard Deviations of ΔE0 (at baseline), ΔE1 (after staining), and ΔE2 (after bleach) of the three resin composites

Procedure	No. of specimen	Time / ΔE	C1 Z250	C2 DenFil	C3 Zenit
Baseline	54	m_0 / ΔE_0	26.25 ±0.81	24.85 ±0.47	14.74 ±0.65
Staining with a tea solution	18	m_1 / ΔE_1	33.67 ±1.08	28.97 ±1.53	19.54 ±0.75
Staining with coffee solution	18		29.77 ±0.27	28.64 ±0.26	17.70 ±0.50
Artificial saliva (Controls)	18		27.35 ±0.70	25.90 ±0.44	15.11 ±0.96
Bleach after coffee staining	18	m_2 / ΔE_2	26.25 ±1.08	24.91 ±0.42	14.55 ±0.64
Bleach after tea staining	18		26.34 ±0.84	24.77 ±0.51	14.77 ±0.64
Bleach after artificial saliva	18		26.51 ±0.67	24.91 ±0.56	13.97 ±0.89

By immersion in tea solution; the most stained resin composite was DenFil microhybrid (C_2) ΔE_3=8.45 followed by Z250 nanohybrid (C_1) ΔE_3=7.54. Nanoceram (C_3) was the least affected by tea staining solution ΔE_3=5.18 (Table 3). Conversely with the coffee solution; DenFil microhybrid (C_3) showed the highest change in color ΔE_3=5.13 followed by Z250 (C1) ΔE_3=3.64. Nevertheless, Zenit Nanoceram was the least color change by coffee solution ΔE_3=3.43 (Table 3).

Artificial saliva caused a little color change for the three resin composites tested specimens after the same period of immersion. The most color changed was DenFil microhybrid (C_2) ΔE_3=1.82, followed by Z250 nanohybrid (C_1) ΔE_3=1.46 Zenit nanoceram (C_3) was the least affected by artificial saliva ΔE_3=0.76 (Table 3)

The color of the three stained resin composites evaluated in this study was found to be changed by the bleaching agent (Opalescence 20% home bleach) and returned near or at the original color shade after two weeks. Zenit Nanoceram (C3) was the most affected one followed by Z250 Nanohybrid (C1), and DenFil Microhybrid (C2) (Table 4). Zenit nanoceram performed better regarding the color stability but was found to be affected more by the bleaching agent compared to DenFil Microhybrid and Z250 nanohybrid composites (Tables 3 & 4).

Statistical analysis (One-way and Two-way ANOVA) revealed that the three tested resin composites were significantly changed in color after immersion in staining solutions (P<0.05). Also, there was a significant change in color of the three resin composite specimens after the application of the bleaching agent (P<0.05). Tukey's Post Hoc test revealed that the three types of resin composite specimens are significantly affected by the tea (P=0.03), and coffee solutions (P=0.02). With artificial saliva, there was a little color change, which is insignificant P=0.07. Application of bleaching agent to the previously stained specimens resulted in returned the color of the stained specimens near or at the baseline color. This means there was no significant difference in the color between baseline and bleached specimens (P>0.05).

Table 3: Mean and ±Standard Deviation of ΔE3 (color difference between baseline & stain)

Resin Composite	Immersion solution	Total No. of specimens	No. of Specimens (per group)	Mean ±(SD)
Z250 C1	Tea	54	18	7.54 ±(1.34)
	Coffee		18	3.64 ±(0.82)
	Artificial Saliva		18	1.46 ±(1.07)
DenFil C2	Tea	54	18	8.45 ±(1.63)
	Coffee		18	5.13 ±(0.50)
	Artificial Saliva		18	1.82 ±(0.78)
Zenit C3	Tea	54	18	5.18 ±(0.88)
	Coffee		18	3.43 ±(0.80)
	Artificial Saliva		18	0.76 ±(1.37)

Table 4: Mean and ±Standard Deviation of ΔE4 (color difference between baseline & bleach)

Resin Composite	Immersion solution	Total No. of specimens	No. of Specimens (per testing group)	Mean ±(SD)
Z250 C1	Tea	54	18	1.76 ±(0.19)
	Coffee		18	1.73 ±(0.10)
	Artificial Saliva		18	0.85 ±(0.26)
DenFil C2	Tea	54	18	1.63 ±(0.22)
	Coffee		18	1.34 ±(0.12)
	Artificial Saliva		18	0.28 ±(0.31)
Zenit C3	Tea	54	18	2.12 ±(0.24)
	Coffee		18	2.33 ±(0.44)
	Artificial Saliva		18	0.92 ±(0.27)

DISCUSSION

Resin composite restorative materials are exposed to saliva, staining foods and drinks in the oral cavity, which can affect the color stability of these aesthetic restorations leading to superficial or internal color change. Clinically several methods have been suggested to overcome the discoloration problem of composite restorations including surface polishing by polishing pastes and discs, application of bleaching materials or even replacement of the restoration if the former procedures were not effective.[2, 16, 24]

The current in-vitro study was conducted to investigate the color changes of three brands of resin composites of the same shade (A2), after exposure to tea, coffee solutions, and artificial saliva. The selection of the composites is based on the fact that the three resin composites have some compositional differences, they are available in the market, and used by many dentists for anterior and posterior teeth. The staining period was kept at 3 h per day because an average person spends approximately 60–180 min per day eating and drinking thus simulating possible staining susceptibility of restorations[11]. Lipton Black Teabags and Nescafé plain coffee were used as staining solutions because they are routinely consumed beverages by the Libyan society at home and in public cafés.

Color assessment varies from person to person and even in one individual at different time points.[14] In this study, to eliminate the subjective errors of interpretation of visual color comparison[8], the color assessment was done using a spectrophotometer. Several studies were performed using this device to determine the color difference of resin composite restorative materials after exposure to several foods and drinks with staining ability. [11, 15, 17, 24] The color measurement was done against a black background to simulate the absence of light in the mouth.[15]

Results of the present study revealed that the color of all composites specimens was significantly changed after exposure to tea and coffee solutions, and also after application of the bleaching agent. However, the tea solution had a more staining effect than the coffee solution. Our findings were in agreement with some studies [10, 25, 25, 26]. On contrary, other studies documented that coffee had the most staining effect on the color of the investigated resin composites.[17, 25] The obtained results could be attributed to the compositional differences between the three resin composites. Dental composites are composed of three chemically-different materials: the organic matrix or organic phase; the inorganic matrix, filler or disperse phase; and the coupling agent to bond the filler to the organic resin.[28] These different materials can play a role in its color stability and affect esthetic properties.[29] Literature reported that staining susceptibility of resin composites is attributed to the degree of water sorption and hydrophilicity of the resin matrix.[14] Excessive water sorption can increase the staining liability of composite restorations.[5] Water sorption leads to expanding and plasticizing the resin component, hydrolyzing the silane, and causing microcracks formation.[2] These microcracks at the interface between the filler and the matrix allow stain penetration and discoloration.[2]

Hydrophilic materials have a higher degree of water sorption and relatively higher discoloration value with staining solutions than hydrophobic materials.[8] This may explain why the three types of resin composite evaluated in the current study were discolored at dissimilar degrees as they have some dissimilarity in the chemical composition and proportions of their matrix (Table 1). Zenit nanoceram was the least affected by both tea and coffee solutions followed by nanohybrid Z250XT, and DenFil microhybrid resin composite which was the most affected one. Authors stated that TEGDMA diluent material increases the hydrophilicity of the resin composite,[29] and can affect its esthetic properties.[2, 8, 29] This may explain why Z250XT and DenFil stained more than Zenit as the latter doesn't contain this monomer. UDMA is more resistant to stain than Bis-GMA.[13, 29] The absence of UDMA in DenFil may explain why it is the most affected one by tea and coffee solutions. Nasim *et al.,*[14] reported that Bis-GMA- and TEGDMA-based resin composites are more hydrophilic than UDMA-based resin composites because of the presence of hydroxyl group in their chemical structure. Consequently, dental materials that contain such monomers may be more susceptible to water sorption and discoloration over time.[2, 14] This fitted with the findings of the current study. Literature documented that microfilled resin composite showed a greater degree of staining because of their higher content of organic matrix.[11, 30] In addition, it has been reported that a composite with large-size filler particles is more prone to water aging discoloration than a composite with small-size filler particles.[2, 24] Thus, water and coloring solutions are absorbed easily causing hydrolytic degradation of the matrix filler interfaces.[5] Accordingly, the staining ability and the high color change of the DenFil microhybrid resin composite evaluated in the current study could be attributed to its filler particle size as compared with Z250XT and Zenit (Table 1). As the size of the filler particles decreases they become difficult to be detached from the matrix, therefore the penetration of solutions including staining one is not easy, hereafter the material is more color stable.[31] This may clarify why Zenit nanoceram showed the most color stability as it had a filler particle size of 12nm from pyrogenic silica. Likewise, Z250XT nanohybrid is more stable than DenFil as Z250XT had a filler size of 20nm from Zirconia. Our results were in agreement with Telang et al.,[15] who concluded that Supranano resin composite was more color stable than Z250XT nanohybrid resin composite. However, in contrast to our results, Villalta et al.,[2] reported that Feltik supreme nanohybrid had more color change than Estht X microhybrid composite.

Furthermore, higher loading of filler particles in Zenit nanoceram (70%) (Table 1) may contribute to the color stability of this material. Although DenFill microhybrid had more filler loading (80%), the larger size of these particles may play an important role in the color change as mentioned previously. Accordingly, it can be assumed that DenFil microhybrid resin composite, in the presence of small-to-large filler particles, with a Bis-GMA and TEGDMA resin-based, is more prone to water sorption and discoloration.[29]

In the present study, noticeable discoloration has been observed in all tested composite specimens. The addition of zirconia and ceramics in recent composite materials to improve esthetic and mechanical properties also may contribute to the resistance to discoloration[15, 25] Farah and Elwi[25] stated that N-Ceram is more stable than nanohybrid Z350 resin

composite which is in agreement with our study. Our results were in agreement with observations of previous studies who found that the effect of staining solutions on color change of resin composites is material dependent and has been primarily attributed to the composition of the resin composite,[8, 29] type of filler particles,[25] and filler particle size.[2, 5, 24]
Literature reported that normal saline[16] or distilled water[14] could be used as immersion solution in the control group. In the present study, the specimens were immersed into artificial saliva[25] to mimic the oral condition.[15] Yet, the specimens of the control group at previous studies used any one of the previously mentioned solutions showed a little and insignificant color change.[14, 16, 25] These results were in accordance with our findings.
Regarding staining solutions, both coffee and tea solutions showed visible discoloration of all resin composite specimens, ΔE_3 (Table 3). This is in line with the findings obtained in previous investigations.[2, 8, 14, 16, 20] Adsorption and absorption can be the cause of tea and coffee discoloration [24]. Both tea and coffee contained yellow colorants with different polarities, which are released and penetrated to the organic part of the materials.[16] This may be due to the matching of the polymeric materials with the yellow color-causing materials in tea and coffee.[25] Higher polarity components (like those in tea) are eluted first, while lower polarity components (like those in coffee) are eluted at a later time.[29] In the same context, Poggio et al.,[31] examined different types of coffee for 28 days and found that all coffee solutions caused a significant color change. According to previous studies, authors suggested that immersion time,[16, 29] and type of discoloring solution[31] are dominant factors in staining resin composite. However, long-term contact with some food dyes such as tea and coffee can considerably affect the color stability of modern esthetic restorative materials regardless of materials type and different compositions.[24, 31]
Concerning the bleaching procedure performed in the present study, the active ingredient of Opalescent 20 home bleach was the 20% carbamide peroxide, which was found to be effective in removing stains from the stained composite specimens. Values of ΔE_4 (Table 4) revealed that the color of stained composite specimens returned near or at the original color, which is in agreement with several studies.[16, 18, 20, 31]
It has been found that after bleaching with 10% and 16% carbamide peroxide, the color of the stained specimens changed to a clinically acceptable color.[25]
The mechanism of bleaching for the teeth is that the active agents (peroxide solutions) can flow freely through the enamel and dentin, and oxidize the pigments in the teeth[2]. In this in vitro study, the bleaching agent was able to remove the stain from the surface of the three resin composite specimens. This was probably due to superficial cleansing of the specimens, not intrinsic color change,[32] because the values of ΔE_4 were near or similar to the original color value. It seemed that the bleaching agents can remove the exterior staining from the specimens but did not bleach them, whereas they can effectively bleach the natural teeth.[18] Therefore, in the clinical practice after bleaching procedures, the composite restoration may not always match the surrounding bleached tooth structure.[16] Further studies using teeth restored with resin composites are needed to gain more insight into the clinical relevance and color match between tooth structure and resin composites after bleaching.

CONCLUSIONS

Under restricted conditions and within the limitations of the present *in vitro* study, the following conclusions may be drawn:
1) The three tested resin composites; nanohybrid, microhybrid, and nanoceram showed variable color change when exposed to tea, coffee, and artificial saliva solutions for 3hrs per day for 28 days. 2) Tea solution had a more stainability effect on the three tested resin composites than the coffee solution. 3) Zenit; nanoceram composite showed the highest color stability (the least affected by staining solutions), and DenFil; microhybrid composite showed the least color stability (the most affected by staining solution). 4) Artificial saliva had an insignificant effect on color stability after the same staining period, although it did change the color of the three tested resin composite specimens. 5) Opalescence 20 home bleach (bleaching agent) was effective in removing stains from previously stained resin composite specimens and restoring the color to near baseline.

Conflicts of Interest: The authors declare no conflict of interest.

REFERENCES

1. Oliveira D. Esthetics of Dental Composites. Dental Composite Materials for Direct Restorations. J Applied Oral Science 2018;17:155-76.

2. Villalta P, Lu H, Okte Z, Garcia-Godoy F, Powers JM. Effects of staining and bleaching on color change of dental composite resins. J Prosthet Dent 2006;95(2):137-42.

3. Janda R, Roulet JF, Latta M, Steffin G, Ruttermann ST. Color stability of resin-based filling materials after aging when cured with plasma or halogen light. Eur J Oral Sci 2005;7:113-251.

4. Magne P, Woong-Seup S. Optical integration of incisoproximal restorations using the natural layering concept. Quintessence Int 2008;39(8):633-43.

5. Janda R, Roulet JF, Latta M, Kaminsky M, Ruttermann ST. Effect of exponential polymerization on color stability of resin-based filling materials. Dent Mater J 2007;23(6):696–704.
6. Kolbeck C, Rosentritt M, Lang R, Handel G. Discoloration of facing and restorative composites by UV-irradiation and staining food. Dent Mater 2006;22(1):63-8.
7. Yap AU, Low JS, Ong LF. Effect of food-simulating liquids on surface characteristics of composite and polyacidmodified composite restoratives. Operative Dentistry 2000;25:170-76.
8. Mundim FM, Garcia Ld-FR, Pires-de-Souz FP. Effect of staining solutions and repolishing on color stability of direct composites. J Appl Oral Sci 2010;18(3):249:54.
9. Barutcigil Ç, Yildiz M. Intrinsic and extrinsic discoloration of dimethacrylate and silorane based composites. J Dent 2012:e57-e63.
10. Reis AF, Giannini M, Lovadino JR, Ambrosano GM. Effects of various finishing systems on the surface roughness and staining susceptibility of packable composite resins Dent Mater 2003;19:12-18.
11. Omata Y, Uno S, Nakaoki Y, et al. Staining of Hybrid Composites with Coffee, Oolong tea, or Red wine. Dent Mater J 2006;25(1):125-31.
12. Vichi A, Ferrari M, Davidson CL. Color and opacity variations in three different resin-based composite products after water aging. Dent Mater J 2014;20:530-34.
13. Garoushi S, Lassila L, Hatem M, et al. Influence of staining solutions and whitening procedures on discoloration of hybrid composite resins. Acta Odontologica Scandinavica 2013;71(1):144-50.
14. Nasim I, Neelakantan P, Sujeer R, Subbarao CV. Color stability of microfilled, microhybrid and nanocomposite resins - an in vitro study. J Dent 2010;38 Suppl 2:e137-42.
15. Telang A, Indiresha H, Narayana K, et al. Effect of Staining and Bleaching on Color stability and Surface Roughness of Three Resin Composites. Contem Clin Dent 2018;9(3):452-56.
16. Poggio C, Beltrami R, Scribante A, Colombo M, Chiesa M. Surface discoloration of composite resins: Effects of staining and bleaching Dent Res J (Isfahan) 2012;9(5):567-73.
17. Borges A, Caneppele T, Luz M, Pucci C, Torres C. Color stability of resin used for caries infiltration after exposure to different staining solutions. Oper Dent 2014;39(4):433-40.
18. Canay S, Cehreli MC. The effect of current bleaching agents on the color of light-polymerized composites in vitro Journal of Prosthetic Dentistry 2003;89(5):474-78.
19. Pruthi G, Jain V, Kandpal HC, PrakashMathur V, Shah N. Effect of Bleaching on Color Change and Surface Topography of Composite Restorations. International Journal of Dentistry 2010;695748:1-7.
20. Hasani E, Baghban AA, Sheikh-Al-Eslamian SM, Sadr A. Effect of bleaching on color change of composite after immersion in chlorhexidine and coffee. J Conserv Dent 2019;22(6) 529–32
21. Brochure for Feltik Z250XT Msi, 3M ESPE 2014, Canada. Nanohybrid.
22. Brochure for Den Fil™ Msi, VIRICOM CO.LTD 2018, USA. Microhybrid.
23. Brochure for ZENIT Msi, president dental 2019, Germany. Nanoceram.
24. Poggio C, Vialba L, Berardengo A, et al. Color Stability of New Esthetic Restorative Materials: A Spectrophotometric Analysis. J functional biomaterials 2017;8(3):26.
25. Farah RI, Elwi H. Spectrophotometric Evaluation of Color Changes of Bleach-shade Resin-based Composites after Staining and Bleaching. J Contemporary Dental Practice 2014;15(5):587-94.
26. Commission Internationale de I'Eclairage: Recommendations on uniform color space. Color difference equations. Psychometric color terms. Suppl 2 to CIE pub 15 (E-13.1) 1971/ (TC-1.3), Paris, France: Bureau Central de la CIE; 1978.
27. Wyszecki G, Stiles WS. Color Sience: Concepts & Methods, Quantitative Data & Formula. 2nd ed. New York: Jhon Wiley; 1982.
28. Van Noort R. Introduction to Dental Materials. 3rd ed. North Carolina.USA: Mosby Inc.; 2007.
29. Malekipour MR, Sharafi A, Kazemi S, Khazaei S, Shirani F. Comparison of color stability of a composite resin in different color media. Dental Research J (Isfahan) 2012;9(4):441-46.
30. Malhotra N, Shenoy RP, Acharya S, Shenoy R, Mayya S. Effect of three indigenous food stains on resin-based, microhybrid-, and nanocomposites. J Esthet Restor Dent 2011;23(4):250-7.

31. Poggio C, Ceci M, Beltrami R, et al. Color stability of esthetic restorative materials: A spectrophotometric analysis. Acta Biomater Odontol Scand 2016;2(1):95–101.

32. Fay RM. Color of restorative materials after staining and bleaching. Oper Dent 1999;24(5):292-96.