Color Stability and Surface Roughness of Ormocer- vs Methacrylate- Based Single Shade Composite in Anterior Restoration

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Research Article

Keywords:

Posted Date: May 23rd, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1656936/v1

Abstract

Background: The blending ability of universal shade composites and their stability in the oral environment are of great concern in restoring anterior teeth. This study aims to evaluate and compare the color stability and surface roughness of two single-shade composite restorations, ormocer-based composite (OBC) and methacrylate resin-based composite (RBC), after storing them in different staining media.

Materials and Methods: In this study, two universal shade composite restorative materials were tested: a nanohybrid OBC (Admira fusion X-tra, Voco) and a supra-nanofilled RBC (Omnichroma, Toukyama). In total, 60 cylindrical centralized cavities (diameter: 5 mm, depth: 2 mm) were prepared in sound extracted-human central incisors and divided into two equal groups according to the restorative material used (n=30). According to the storage media, the teeth of each group were divided into three subgroups (n=10): artificial saliva, black tea, and cola. The restoration color was evaluated for all teeth at baseline and after four weeks of storage. The color stability (Δ E) was measured using a reflective spectrophotometer (X-Rite, model RM200QC, Neu-Isenburg, Germany). The surface roughness (Ra) was evaluated using three-dimensional optical profilometry (Wyko, Model NT 1100, Veeco, Tucson, USA). Additionally, the extracted data were analyzed using two-way analysis of variance (ANOVA), one-way ANOVA and Student's *t*-test.

Results: In the baseline evaluation, there were no statistically significant differences with respect to color matching or surface roughness results between the two studied restorative materials. However, the differences were statistically significant after storing them in different media.

Conclusion: Universal composites showed satisfactory color matching with different teeth colors and accepted surface smoothness, whereas the aging procedure exerted a negative effect on their color stability and surface characteristics.

Introduction

Currently, resin-based composites (RBCs) are widely used for anterior teeth because of their satisfactory aesthetics, preservation of the tooth structure, low cost and good mechanical properties.[1] Technological progress in the development of RBCs has brought improvements in both filler and organic matrices. Changes in fillers, especially in the size, distribution, and type of particles, have occurred in the past few years and have enhanced the mechanical and optical properties of composites.[2] Moreover, monomer progression improves both the polymerization reactivity and the mechanical properties of the adhesive layer formed. Both Bis-GMA and UDMA dimethacrylates have become the primary monomers that are broadly utilized today for most dental composites. Because of its high viscosity, it is important to add low molecular weight monomers to accomplish suitable viscosity for the final formulation that is used clinically. These diluent monomers increase the water sorption, polymerization shrinkage, and discoloration of the composite resin. New monomers have been investigated, aiming to enhance the composite restorative material properties.[3]

Ormocer is the acronym for organically modified ceramic. Their production is based on hydrolysis and polycondensation reactions (sol-gel processing) to create a molecule with a long-chain inorganic silica backbone and lateral organic chains.[4] The composites with ormocer are claimed to demonstrate a higher degree of conversion, minimal polymerization shrinkage, color stability, toughness, and increased surface hardness as a result of the formation of a more highly cross-linked polymer network. Another ormocer advantage would be the higher biocompatibility because the increased number of chemical bonds among the methacrylate groups would decrease the amount of free unreacted monomers in the polymer network.[5]

Color matching of the composite restoration to the tooth structure and its stability has been a considerable challenge for a long time; hence, the RBCs were modified over the years, with enhanced optical properties and a higher availability of opaque/translucent shades.[6] The availability of different shades and technique sensitivities render shade selection a very complicated process, as it greatly depends upon the dentist's skill, bias, and desired outcomes. Certain conditions elicit dentists to use trial and error, which can develop an unacceptable shade that needs the steps to be revamped at the expense of the dentist's chair time. Hence, there is no standardization of the optical properties for these categories, and there may be unexpected or disappointing results.[7]

These difficulties prompt researchers to return to simplifying and decreasing the number of shades based on color interactions. The chameleon or blending effect is the ability of dental materials to show color shifting toward the surrounding dental hard tissue color, which decreases the number of shade guide tabs and recompenses the color mismatches to some extent.[8] The simplification process of color matching starts with the group-shade composites until the production of a universal shade composite material that claimed to match different tooth shades.

One of the most critical factors that affect the aesthetics of the restoration is its surface topography, as a smooth surface enables better optical compatibility with the enamel tissue and surface gloss, along with the prevention of the staining and discoloration of the restoration. These materials face persistent chemical degradation in the oral cavity because of diets that have a variety of acidic and colored drinks and food. Composites have been shown to withstand these factors and preserve their esthetics.[9]

According to the abovementioned observations, manufacturers have claimed that the universal shade composites have smart chromatic technology that enables them to mimic any tooth shade. As there is scarce information and data about their blending capacity and stability after aging, there is an increased need for further studies.

Materials And Methods

Two single-shade composite restorative materials with their adhesives were used according to the manufacturer's instructions. The full description of these materials is presented in Table 1.

Table 1
Materials evaluated in this study

Material	Type	Composition	Batch Number	Manufacturer	Application procedure
Admira Fusion X-tra	Nanohybrid ORMOCER based composite	Matrix: Resin ORMOCER Filler: Silicon oxide nano filler, glass ceramics filler (1 µm) Filler content: 84 (w/w)	1604218	VOCO GmbH, Cuxhaven, Germany	The restoration was applied at layers that are a maximum of 4 mm thick and adapted with a composite modeling instrument (CompoRoller,Kerr) and light-cured for 40 seconds
OMNICHROMA	Supra nano filled composite	11, 6- Bis-methacryl ethyl oxycarbonyl amino, UDMA, TEGDMA, Mequniol, Di-butyl hydroxyl toluene and UV absorber. Filler content: 79 (w/w) of spherical silica-zirconia filler mean particle size: 0.3 µm	1602201	Tokuyama Dental, Tokyo, Japan	Resin composite was applied incrementally that are a maximum of 2.5 mm thick and adapted with a suitable instruments. each increment was photopolymerized individually for 20 seconds
Futurabond M+	Single bond universal LC	2-HEMA (10%-25%), Bis-GMA) (10%-25%),ethanol (10%-25%), acidic adhesive monomer(10 MDP) 2.5%-5%),UDMA(2.5%-5%),catalyst, pyrogenic silicic acids pH 2.3	1929068	VOCO GmbH, Cuxhaven, Germany	One drop of the bond was put on a mixing palette, then the adhesive was applied evenly to the surfaces of the cavity and rubbed it in for 20 seconds with a disposable applicator, after that the adhesive layer was dried off with dry, oil-free air for at least 5 seconds in order to remove any solvents, then the adhesive layer was cured for 10 seconds

Material	Type	Composition	Batch Number	Manufacturer	Application procedure
Palfique Universal Bond	Self-cured dental universal adhesive	Phosphoric acid monomer, Bis phenol A di (2-hydroxy propoxy) dimethacrylate), Bis-GMA, TEGDMA, 2- HEMA, (MTU-6). Silane coupling agent, peroxide, Borate catalyst, Acetone. Isopropanol and purified water.	040EZ8	Tokuyama Dental, Tokyo, Japan	One drop of each bond bottle (A and B) was put on a mixing palette and mixed thoroughly with a disposable applicator, the application was completed within one minute since it had volatile solvents, after mixing the color had changed gradually, the application was completed within 3 minutes, then the adhesive was applied evenly to the surface then air dry for 30 seconds
Etchant Gel Vococid		35% orthophosphoric acid	7523	VOCO GmbH, Cuxhaven, Germany	
Etching Gel HV		39 wt% phosphoric acid	162E69	Tokuyama Dental, Tokyo, Japan	

Methods

Teeth Selection

In total, 60 freshly extracted maxillary central incisors were chosen from the Oral Surgery Clinic, Faculty of Dentistry, Mansoura University for this study. The teeth were indicated for extraction for periodontal reasons and were extracted from a healthy patient after the signing (approval) of a written informed consent- form by the patient. All teeth were examined under a stereomicroscope (10× magnifications) to rule out the existence of fissures, fractures, carious lesions, restorations, and erosion or abrasive lesions. Thereafter, the teeth were scaled and polished using a rubber cup and pumice. The teeth were stored in distilled water and kept in a deep freezer for 24 hours (-10°C°) to avoid changes in the optical properties of the teeth. [2]

Cavity Preparation

Cylindrical shaped cavities (diameter: 5 mm; depth: 2 mm) were prepared at the center of the crown by dividing each tooth into three sections vertically and horizontally. In the middle part, a premeasured template was supported for a uniformly shaped outline for all the preparations (Fig. 1a, b).[10] Cavity preparations were performed using carbide burs No. 330 on a high-speed handpiece with air/water coolant (W&H, SN 0012845); each bur was marked at 2 mm from its top and the final depth was checked by a periodontal probe. Importantly, each bur was used to preform five cavities. All cavosurface angles were kept at 90° without bevel designs. Two-thirds of the root was cut off, and the pulp chamber was blocked using resin composite.

Specimen Grouping

The prepared teeth were randomly divided into two equal groups (n = 30): group 1 was restored with nanohybrid OBC, and group 2 was restored with supra-nanofilled RBCs. All the restorative materials and their bonding systems were utilized according to the manufacturer's instructions. Additionally, they were finished immediately with a superfine diamond grinder (25 µm) attached to a high-speed handpiece at 200,000 rpm under water cooling systems for 10 seconds to simulate the initial tooth contour. Then, the teeth were polished with an aluminum oxide disc system (Sof-Lex, 3 M ESPE, 44-0007-7442-0-A lot N664515, St Paul, MN, USA). Numbers were assigned to each tooth to differentiate the teeth in each group during thermocycling and ensure the examination of the same tooth immediately and after aging procedures.

Staining Procedures

Each group was divided into three subgroups (n = 10), and each subgroup was further immersed in different storage media. The teeth were waterproofed with a colorless nail polish on their bucal and lingual surfaces. The staining solutions used were: artificial saliva, tea, and cola (Table 2).

Table 2
Type, ingredients and pH of the immersion media tested in this study

No.	Solvent	Ingredients	pH
1	Distilled water	Used as control and to investigate intrinsic color changes in restorative material	7.2
2	Artificial saliva	Sodium biphosphate 23%. Sodium chloride 11.8%, potassium chloride 11.8%, urea 29.5%	6.9
3	Black tea	Caffeine, tannins, theophylline, vitamin, glucose	5.05
4	Coca cola	Carbonated water, high fructose corn syrup, caramel color, coca flavor, phosphoric acid, caffeine.	2.5

- Subgroup (a): The teeth were stored in 150 ml of artificial saliva that was prepared in the Pharmaceutics Department, Faculty of Pharmacy, Mansoura University.
- Subgroup (b): The teeth were stored in a black tea solution that was prepared by immersing 1 prefabricated tea bag (Black Tea Lipton, Egypt) into 100 ml of boiling distilled water for 5 minutes.
- Subgroup (c): The teeth were stored in carbonated soft drink or cola (Coca-Cola, Egypt). The containers' lids were closed tightly to prevent the leaking of carbonic gas to maintain an acceptable carbonic gas level, and a new bottle was used daily.

The specimens were kept in staining solutions and further in an incubator (BTC, Model: BT1020, Egypt) at 37°C over a 28-day test period.[11] Additionally, a digital pH- meter (CONSORT nv, Parklaan 36,B2300 Turnhout, Belgium) was used to measure the pH of fresh immersion liquids. Each specimen was rinsed for 30 seconds in distilled water and cleansed gently with a soft bristle toothbrush to expel any loose sediment caused by the immersion solution during the incubation period. The same rinsing process was repeated daily. Furthermore, the three storage liquids were refreshed daily to prevent microbial growth and kept in vials with lids that inhibited the evaporation of staining solutions. All the teeth were handled carefully from the root to prevent any surface scratches.

The specimens were thermocycled (SD Mechatroniks thermocycler, Germany) for 3500 cycles between water paths held at 5°C and 55°C with 15 sec dwell time in each bath.[12] Thereafter, the teeth were rinsed gently with distilled water and air-dried.

Color Stability Evaluation

For each group, the baseline specimen color was measured by a reflective spectrophotometer (X-Rite, model RM200QC, Neu-Isenburg, Germany). The teeth were aligned with the device and the aperture size was adjusted to 4 mm. A white background was selected and the measurements were conducted using the CIE L*a*b* color space affined to D65; the CIE standard illuminant. The specimen color changes (ΔE) were estimated according to the following formula: [13]

$$\Delta E_{CIELAB} = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{½}$$

where L* = lightness (0- 100), a* = (color change of the axis (red/green)) and b* = (color variation axis (yellow/blue)). A perceptible color change, that is ΔE* > 1.0, will be considered acceptable up to the value ΔE* = 3.3. Importantly, subjective *in vitro* visual assessments were conducted under optimal lighting conditions.[14] The color was measured at four fixed points (diamond shape) on the restoration and their adjacent points on the tooth surface, and an average of these readings was taken to represent each restoration color (Fig. 1c). After storage and thermocycling, the specimen color was examined in the same manner. Next, ΔE between the delayed and baseline results was established.

Surface Roughness Evaluation

A 3D optical profilometer noncontact (Wyko, Model NT 1100, Veeco, Tucson, USA) attached to a PC with image software (Vision 32, Veeco, USA) was used to measure the surface roughness.[15] The software used for creating the images supplied arithmetic roughness mean (Ra) data based on the peaks and valleys exhibited in the analyzed area. Thus, a 3D image of the specimen surface profile was produced. Thereafter, five 3D images were gathered for each specimen in the central and side areas of 10 µm × 10 µm.

Data were tabulated, coded, and anatomized with the Statistical Package for Social Science (SPSS) computer program version 26.0 to produce the descriptive data. The calculation of descriptive statistics was conducted in the form of mean and standard deviation (SD). Two-way analysis of variance (ANOVA) followed by Bonferroni post- hoc test was used to detect the effect of restorative materials and coloring media on color stability. One-way ANOVA followed by post- hoc Tukey's test was used to define the statistically significant differences between the restorative materials kept in each medium. Additionally, Student's *t*- test (paired, unpaired) was utilized to compare the mean values of parametric data between the two groups (P value < 0.05 was considered statistically significant).

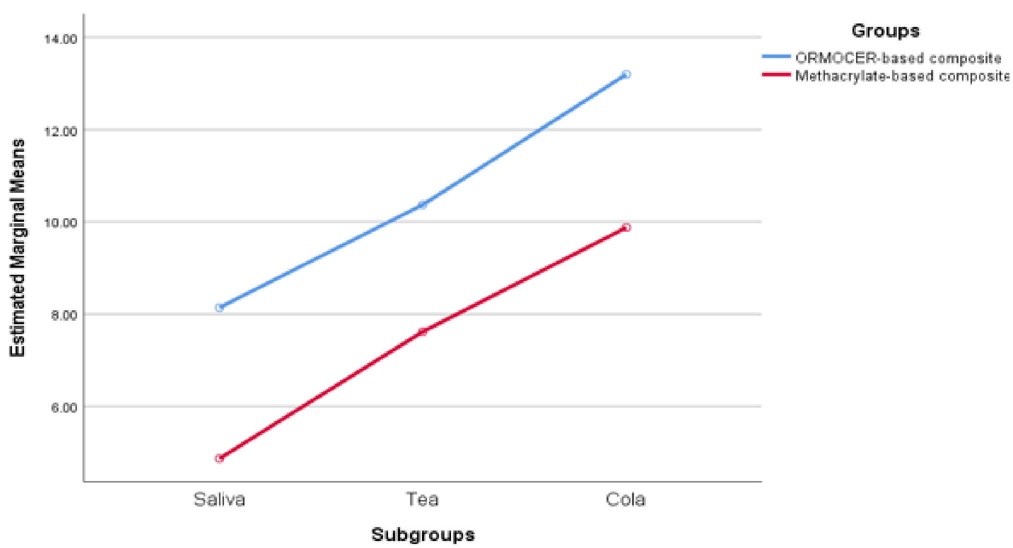
Results

Color Stability Results

Two-way ANOVA test outcomes exhibited no significant interaction between the restorative material type and the coloring agents used ($P = 0.689$). One-way ANOVA for OBC established statistically significant differences between the specimens after storage in different coloring media ($P < 0.001$). Afterwards, the Tukey test illustrated these differences among subgroups, as there were significant differences among the tea and saliva subgroups ($P = 0.003$). Moreover, there was a significant difference between cola and saliva ($P < 0.001$); moreover, there was a significant difference between cola and tea ($P < 0.001$). For RBCs, statistically significant differences were established after storage in coloring media ($P < 0.001$). The Tukey test showed statistically significant differences between the following subgroups: tea and saliva, cola and saliva, and tea and cola ($\Delta E < 0.001$). Student's paired *t*- test showed significant differences between the baseline and delayed results for each restoration (P < 0.001); whereas Student's unpaired *t*- test showed no significant differences between the baseline results of the materials (P > 0.05). However, there was a statistically significant difference among the delayed results (P < 0.001). These outcomes are summarized in Table 3.

Table 3
Mean and standard deviation for the Color Stability of the two studied universal shade composites.

	ORMOCER-based composite		**Methacrylate-based composite**	
	ΔE-Baseline	**ΔE-Delayed**	**ΔE-Baseline**	**ΔE-Delayed**
Saliva	**3.30 ± .82**	**8.14 ± 1.14#**	**2.99 ± .62**	**4.87 ± .77*#**
Tea	**3.31 ± .78**	**10.37 ± 1.13#a**	**3.43 ± .52**	**7.62 ± 1.17*#a**
Cola	**3.26 ± .76**	**13.19 ± 1.70#bc**	**3.11 ± .98**	**9.87 ± .79*#bc**
Data are expressed as the mean ± SD.				
SD: standard deviation P: Probability significance when < 0.05				
*: significance between methacrylate-based composite vs ORMOCER-based composite either at baseline or delayed time (test used: Unpaired Student's t- test).				
#: significance between Delayed vs Baseline either methacrylate-based composite or ORMOCER-based composite (test used: Paired Student's t- test).				
a: significance between Saliva & Tea, b: significance between Saliva & Cola, c: significance between Tea & Cola (test used: one way ANOVA followed by post- hoc Tukey)				



Surface Roughness Evaluation Results

Two-way ANOVA results showed no significant interaction between the tested composite materials and coloring media (P = 0.75). One-way ANOVA for OBC established statistically significant differences among specimens in different coloring media after storage (P < 0.048). Afterwards, the Tukey test showed the differences among the subgroups, as there were significant differences between cola and saliva (P < 0.045), whereas no significant differences were established between the other subgroups (P > 0.05). For RBC, statistically significant differences were established after storage in coloring media (P

< 0.001), and the Tukey test showed statistically significant differences between the subgroups cola and saliva, along with tea and cola ($P < 0.05$), whereas no statistically significant difference manifested between the subgroup of tea and saliva ($P > 0.52$). Student's paired *t*- test showed significant differences between the baseline and delayed results for each restoration ($P < 0.05$), except for the saliva subgroup, whereas Student's unpaired *t*- test showed no significant differences between the baseline results of materials or their delayed results ($P > 0.05$). These outcomes are summarized in Table 4 and Fig. 2.

Table 4 Mean and standard deviation for the surface roughness of the two studied universal shade composites.

	ORMOCER-based composite		Methacrylate-based composite	
	ΔR-Baseline	ΔR-Delayed	ΔR-Baseline	ΔR-Delayed
Saliva	0.253±0.0023	.253±0.0046	0.254±0.0031	0.255±0.0009
Tea	0.252±0.0035	.254±0.002#	0.255±0.002	0.256±0.0014
Cola	0.253±0.003	.257±0.002#b	0.256±0.0019	0.258±0.0017# bc

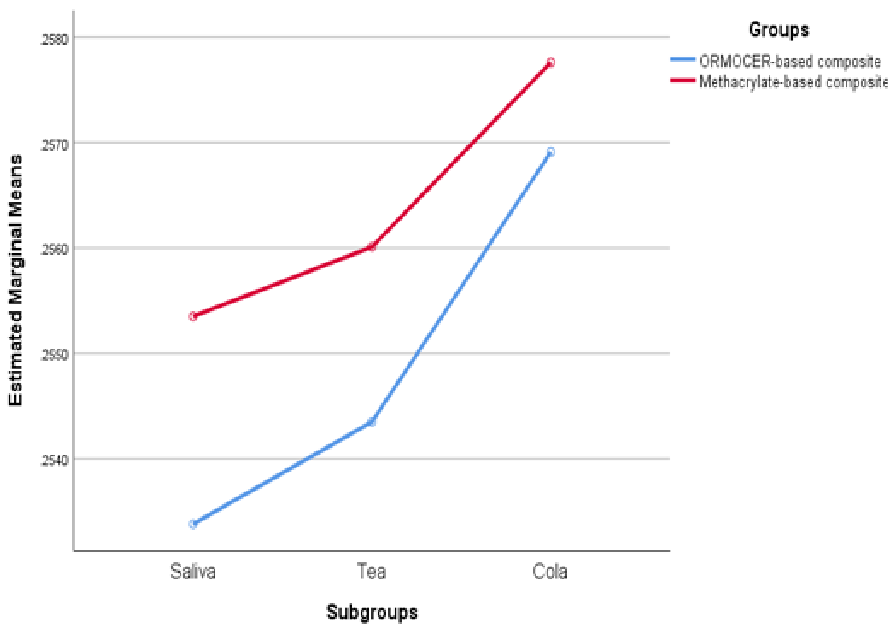
Data are expressed as the mean±SD.

SD: standard deviation P: Probability significance when <0.05

*: significance between Methacrylate-based composite vs ORMOCER-based composite either at baseline or delayed time. (Test used: Unpaired Student's t-test)

#: significance between Delayed vs Baseline either methacrylate-based composite or ORMOCER-based composite (test used: Paired Student's t- test)

a: significance between Saliva & Tea, b: significance between Saliva & Cola, c: significance between Tea & Cola(Test used: one way ANOVA followed by post -hoc Tukey)



Discussion

Creating an aesthetic anterior composite restoration has been an exacting challenge for a long time because of the limitations of many materials that affect either shade integration or surface quality and probably color stability. In addition to the drawbacks in technology, a lack of predictability and certain complexity in the clinical application were inherent to the technique and produced its elitist for a long time. Universal shade composites claimed to have a breakthrough in dentistry that has an impact on treating all these problems.[16]

Universal shade composites are based mainly on structural color phenomena. Structure colors are the result of the fundamental optical processes of interference, scattering or diffraction. Subsequently, unlike traditional pigmented color that comes from the light absorption of pigments, structural color claimed to be more adequate and stable. In this study, two omni-chromatic universal shade composites were chosen with different organic matrix structures, as the matching between refractive indexes between the organic matrix and the fillers is one of the fundamental issues to achieve structural color.[17] Moreover, the OBC used some pigments in its structure, while RBC color was purely based on the structure color concept.

In this study, the employed methodology was in accordance with previous studies. Every effort made to ensure the standardization of the methodology, as well as all the steps, was performed by a single operator. The extracted human teeth were used as the studied materials to gain their color by induction from the surroundings. In addition, natural teeth have different optical properties, so they were used to reveal the clinical conditions. The series of Sof-lex polishing discs was the system of choice. Aluminum oxide discs have been suggested as a standard protocol because of their capability to form smooth, nondestructive polished surfaces that are less susceptible to chemical solubility.[18] The studied liquids were chosen as colorant agents because of their constant consumption in daily life. A four-week immersion period was chosen, which is equal to approximately 2.5 years of clinical aging (24 h of staining in vitro corresponds to about 1 month in vivo, and 3,500 thermal cycles were performed to mimic the oral environment during this period).[12]

Spectrophotometry and the CIE L*a*b* coordinate systems are recommended methods for dental purposes. The CIE L*a*b* coordinate system was selected to evaluate the color variation (ΔE) because it is well suited to determine the small changes in color and has advantages such as objectivity and sensitivity. Additionally, it enhances the reliability of shade matching and shade communication.[19] A noncontact digital profilometer microscope was used because of its ability to scan the surface with a type of laser and provide a 3D surface map without damaging the specimens, thereby proving to be a fast and easy evaluation method.[20] The surface roughness over the roughness threshold (Ra = 0.2 μm) causes a simultaneous increase in biofilm accumulation, and no further decrease in bacterial adhesion could be observed under the threshold value. [15] Smooth surfaces add to the comfort of the patient as a surface roughness change of 0.3 μm can be identified by the tip of the tongue.[21]

Based on this study's results, there were no significant differences at baseline color measurements between OBCs and RBCs. The ΔE values for OBC were 3.2 and 3.1 for RBC, which are considered clinically acceptable. This finding may be attributed to the unique pure silicate technology of OBC restoration, as manufacturers claimed that its nanoparticulate amplifies the chameleon effect, further reinforcing its ability to blend and adapt to the surrounding tooth structure because it is smaller than the wavelengths of visible light. Therefore, its nanoparticulate neither diffracts nor refracts light, but allows the light to pass through uninterrupted and bounce off the surrounding tooth structure.

Moreover, the smart chromatic technology of RBCs, a unique technology based on fillers (uniform supra-nano spherical fillers and round fillers, fabricated with zirconium dioxide and silicon dioxide) that are claimed to generate red to yellow structural color, as light passes through the fillers, reflects the red to yellow range of colors found in all the teeth. These colors then combine with the surrounding tooth color, thus permitting the unprecedented ability of color matching. Consequently, the cured composite blends with the surrounding tooth structure.

These results agreed with those of Bakti I et al., [22] who concluded that nanofilled RBCs exhibit a chameleon effect whereby they can adjust their color to suit that of their surroundings. They also concluded that the chameleon effect has a limitation in its color adjustment. Additionally, Abdel Rouf R et al [23] assessed the visual color matching and blending effect of universal RBCs and concluded that universal composites showed an acceptable color matching, but it may not be the optimal selection when esthetic is the patient's prime concern. These results may occur due to the differences in the materials used. In contrast, de Abreu JLB et al [24] and Iyer RS et al [25] reported that the color matching of single-shade composite is inferior to that of multishade composite, which may limit their clinical use in the cases of high esthetic demand.

After the staining process, the null hypothesis stating that color matching measurements would not be affected after storage was rejected, as all the tested groups of restorations showed a significant increase in ΔE, which was clinically unacceptable. In OBC (mean ΔE for saliva = 8.14 ± 1.14 < for tea = 10.37 ± 1.13 < for cola = 13.19 ± 1.70) which were significantly higher than those for RBC, the mean ΔE for saliva = 4.87 ± .77 < for tea = 7.62 ± 1.17 < for cola = 9.87 ± .79). Cola subgroups had the highest significant difference.

Color changes can be attributed to the combination of matrix degradation by acids, penetration/absorption of colorants into the material as well as the surface adhesion/adsorption of colorant.[26] Immersion in saliva may lead to a yellowish color for restoration because it contains mucin.[27] Additionally tea is rich in tannins, which promotes yellowish staining as it enhances the chromogens' ability to adhere to the materials' surfaces; moreover, immersion in tea increases the surface roughness, hence causing further stain updates.[28] Studies have shown that black tea and tannin-containing compounds cause chemical reactions due to the presence of denaturing factors that lead to stable discoloration.[29] Cola is a yellow-brown carbonated beverage that causes staining due to sulfite ammonia caramel. It also has a decolorizing effect that affects the sorption and solubility of RBC material.[30, 31]

Additionally, the effect of thermocycling, is a combination of thermal and hydrolytic degradation, and is considered a method that simulates temperature-related breakdown by sudden repeated changes in temperature, thereby affecting the durability of the material. Water absorption impacts the mechanical characteristics of composites toward hydrolytic degradation. It can also lead to microfractures in the interface between the resin matrix and the fillers and induce superficial stress due to high temperature gradient differences, which are close to the surface and affect its roughness and the ability to gain stains.[32]

These results were in accordance with those of Reddy PS, et al, [33] and Ozkanoglu S et al,[34] who reported that in vitro staining affects the color match of esthetic restorations. They also concluded that the staining intensity of cola is greater than that of tea. Additionally, Pordan et al, [35] assumed that specimens immersed in saliva exhibited color changes compared to baseline, and these changes were attributed to the water sorption characteristics of the restorations. In contrast, the results of previous studies were not in agreement with this study, [29, 30] that is; tea had a higher staining ability than that of cola.

There were no significant differences in surface roughness between the two studied composites either immediately or after storage is accepted, as the average Ra for OBC was 0.253 and 0.254 for RBC which is considered clinically acceptable in terms of bacterial adhesion and patient comfort. These results may be attributed to the fact that the manufacturing of the nanoparticles in both materials was the same which is called the sol-gel process. This process is a controlled reaction between different chemistries that results in the creation and growth of uniform nanospheres (nanoparticles) that are harvested once they grow to the desired diametrical size, (the nanoparticles' diameter in OBC = 20–40 nanometers), whereas RBC fillers were based on their own patented "Sub-Micro-Pearl-Technology". In this process, the Sol-Gel method is used to progressively coat the spherical fillers in an organic solution. After several weeks, the fillers have "grown" evenly in a spherical shape and are exactly 0.26 µm in size. This feature results in a highly smooth polished surface.[13]

This result was in accordance with that of Cunha LG et al and Gurbuz A et al, [36, 37] who concluded that OBC did not present significant differences compared to the surface roughness of the conventional composites because of the comparable filler size and load between them. However, Tagtekin DA et al,[38] concluded that ormocer had a higher surface roughness than conventional hybrid RBC as the filler particles in the used ormocer are harder than the matrix, causing preferential loss through finishing and polishing, as well as leaving the filler phase in a positive surface and causing more surface roughness.

After staining, there was no significant difference between the control groups (distilled water) and those stored in saliva; however tea and cola caused a significant increase in the surface roughness of both composites. These results were in agreement with previous studies[39] and may be ascribed to the chemical erosion from tea as it contains oxalic, malic, and citric acid with a pH (value of 5.4), which is acidic in nature. Additionally, cola has a low pH (value of 2.5) that influences the surface integrity of the RBC, thereby leading to an increasing surface roughness. The lower pH of cola with respect to tea can explain the significant difference between their RBC results. [33, 40]

All clinical conditions are difficult to replicate with high precision in a laboratory study; subsequently, further clinical investigations are still necessary to predict the acceptability and longevity of universal shade composite restorations.

Conclusion

Within the limitations of this *in vitro* study, the following conclusions can be drawn:

1. Universal shade composites have a satisfactory color matching to different teeth colors and accepted surface roughness immediately.
2. Staining agents exert a negative effect on the color blending ability and surface roughness.
3. Cola soft drink had the highest effect on the color stability with respect to the restoration and surface quality.

Declarations

Ethical approval and consent to participate

All procedures performed in this study, were carried out in accordance with relevant ethical guidelines and regulations of Helsinki Declaration. All experimental protocols were approved by the Ethics Committee, Faculty of dentistry, Mansoura University with reference number “A24080120”. Written informed consent was obtained from all participants.

Consent for Publication

Not applicable

Competing Interest

The authors declare that they have no competing interest.

Funding

None

Acknowledgement

The authors would like to express their thanks to Pharmaceutics department, Faculty of Pharmacy, Mansoura University for their valuable assistance in solutions preparation.

Author Contribution

S.M planned and supervised the study. A.A and H.E helped with the statistical planning and analysis. M.E took the lead in making all the study procedures and writing the manuscript. All authors discussed the results, provided critical feedback and helped shape the research, analysis and manuscript and have all contributed to the final version of the manuscript. All authors have read and approved the final manuscript.

Availability of Data and Materials

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

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Figures

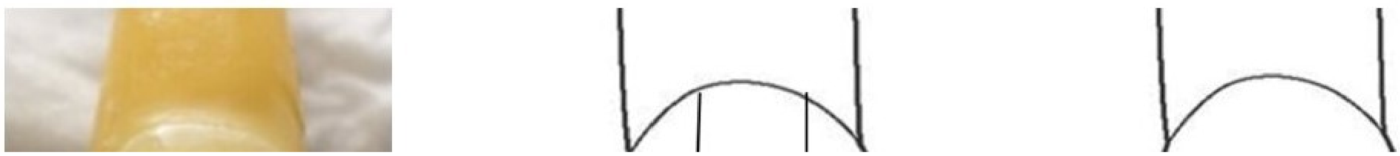

Figure 1

a: Cavity preparation , b: Cavity measurements, c: Color measurements; trapezoidal shape figure within the restoration with 4 apexes (a: cervical, b: mesial, c: incisal, d: distal to represent all restoration colors, each one away 1 mm from restoration margin, while the other measuring points (a1,b1, c1, d1) located within tooth 1 mm away from the restoration margin.

Figure 2

Surface topography of universal shade composites. a; OBC immediately, a1, OBC after storage in saliva, a2. In tea, a3. In cola, b; RBC immediately, b1. In saliva, b2. In tea, b3. In cola.