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ARTIFICIAL ACCELERATED AGING EFFECTS ON THE COLOR AND GLOSS STABILITY OF MODERN UNIVERSAL RESIN COMPOSITES: AN IN-VITRO STUDY

Khaled Wagih Al–Saudi*, Omar Nabil Badran *, Sarah Mohsen Mohamed * and Aalaa Mohamed Nabil Amin**

ABSTRACT

Background: Progression in filler technology has given rise to the introduction of modern universal resin composites, which simplify shade selection; however, their performances after artificial accelerated aging are yet to be examined and verified.

Objectives: To evaluate and compare the color and gloss stability of different modern universal composites submitted to different periods of artificial accelerated aging.

Materials and Methods: Forty disc-shaped composite specimens were fabricated, cured and polished then divided into four groups (n=10): (G1; Omnichroma, G2; Filtek Universal Restorative, G3; TPH Spectra ST, G4; Filtek Z350 XT). Color and gloss were measured before and after exposing to weathering device for (100, 200, 300 hours). The color change (ΔE*) was assessed with a spectrophotometer. The surface gloss was calculated using a glossmeter. Results were statistically analyzed using repeated measures ANOVA test followed by Bonferroni's post-hoc test ($P \leq 0.05$).

Results: ΔE* was observed to be a positive linear function of log time. ΔE* was maximal in the sequence; Filtek Z350 XT = TPH Spectra ST > Omnichroma > Filtek Universal Restorative. ΔE* remained < 3.3 for Filtek Universal Restorative and Omnichroma. Gloss was observed to be a negative linear function of log time. Gloss was maximal in the sequence; Omnichroma > Filtek Universal Restorative > Filtek Z350 XT > TPH Spectra ST.

Conclusions: Omnichroma and Filtek Universal Restorative demonstrated superior performance in color and gloss stability compared to TPH Spectra ST and Filtek Z350 XT.

KEYWORDS: accelerated aging; color; gloss; modern composites

* Lecturer of Restorative Dentistry Department (PhD), Faculty of Dentistry, Nahda University, Beni-Suef, Egypt
** Lecturer of Restorative Dentistry Department (PhD), Faculty of Dentistry, Modern University for Technology and Information, Cairo, Egypt

INTRODUCTION

The recent evolution in composite materials has led to the development of modern universal resin composites with unique nanofillers technology, which allows a larger number of particles that encourages scattering of visible light providing more efficient color agreement with tooth structure [1,2]. Developers have lately created "single" and "group shaded" universal resin composites in an effort to facilitate the shade choosing procedure and improve the final cosmetic outcomes. Single shade composites are those that employ only mono-shade, which could probably blend with all VITA classical shades while group shaded composites utilized fewer shades for a definite group of VITA classical shades [2,3].

Despite recent material improvements that enhance esthetic properties of modern universal resin composites, there is still a concern about their clinical performance, particularly their color and gloss instabilities, which are two of the predominant factors accountable for the replacement of anterior composite restorations after prolonged exposure to oral cavity environment [4,5].

Endogenous color change is mostly related to inherent characteristics of the restorative material such as component of the resin matrix, filler particles loading and size, kind of photo-initiator system, and percentage of residual unreacted monomer whilst exogenous color change is associated with the infiltration of various coloring agents of foods or drinks into the dental filling surface [6].

Gloss plays a rather vital function in esthetic dental restorations. A rougher non-glossy restoration surfaces can easily accelerate plaque accumulating, gingival enlargement and subsequent periodontal inflammation, whereas glossy smooth surfaces reduce plaque aggregation, bacterial adhesion, recurrent caries and the discoloration of restored teeth over the long-term [7].

Artificially accelerated aging provides the most accurate modelling of long-term clinical situations in a short amount of time. It uses visible light, UV radiation, wet and dry environments, and heating cycles to investigate the performance of tooth-colored restorations [5].

Therefore, it is worthwhile to evaluate and compare the color and gloss stability of different modern universal composites submitted to different periods of artificial accelerated aging. Three null-hypotheses were evaluated: (1) Artificial accelerated aging might not induce changes in color; (2) Artificial accelerated aging might not induce changes in gloss; and (3) there might be no difference between different modern universal resin composites.

MATERIALS AND METHODS

The modern universal resin composites are shown in **(Table 1)**. Shade A2 was chosen when resin composite was manufactured in multiple shades [8].

Sample Size Calculation

This power analysis used color change (ΔE^*) as the primary outcome. Based upon the results of a pilot study conducted on three specimens in each composite group, the effect size (f) for a repeated measures ANOVA "within-between interaction" was 0.707. Using alpha (α) level of (5%), β level of 0.8 (Power = 80%); the minimum estimated sample size was a total of 40 specimens (10 specimens per composite group). Sample size calculation was performed using G*Power version 3.1.9.2.

Specimens Fabrication

Disc-shaped specimens (diameter: 10 mm, height: 2 mm) were fabricated for each tested restorative material by utilizing a split-Teflon mold [7]. A single increment of the uncured composite was packed into mold using a Thompson spatula (Quinelato, Sao Paulo, Brazil) then coated on both

TABLE (1): Information on the modern universal resin composite employed in this study.

Material	Manufacturer (Lot No.)	Filler type, size and average	Filler loading	Monomer
Omnichroma (OC)	Tokuyama Dental, Tokyo, Japan (035E01)	Spherical supra-nano SiO_2-ZrO_2 (260nm) and composite fillers.	79% by wt (68% by vol)	UDMA, TEGDMA
Filtek Universal Restorative (FU)	3M Oral Care, St. Paul, MN, USA (NC43910)	Non-agglomerated/non-aggregated (20nm silica, 4-11nm zirconia), an aggregated (20nm silica and 4-11nm zirconia), and agglomerated ytterbium trifluoride filler (100nm).	76.5% by wt (58.4% by vol)	AUDMA, AFM
TPH Spectra ST HV (ST)	Dentsply Sirona Inc., York, Pennsylvania, USA (2106000127)	Spherical, pre-polymerized SphereTEC fillers (15µm), barium glass and ytterbium fluoride.	79% by wt (61% by vol)	Urethane modified Bis-GMA, Bis-EMA, TEGDMA
Filtek Z350 XT (FZ)	3M Oral Care, St. Paul, MN, USA (NA11466)	Non-agglomerated/non-aggregated zirconia/ silica fillers and aggregated zirconia/silica cluster fillers (20nm silica and 4-11nm zirconia fillers) with average cluster particle size (0.6-10μm).	78.5 by wt% (63.3% by vol)	UDMA, Bis-GMA, Bis-EMA, TEGDMA

UDMA: Urethane dimethacrylate, TEGDMA: Triethylene glycol dimethacrylate, AUDMA: Aromatic Urethane Dimethacrylate, AFM: Addition-Fragmentation Monomer, Bis-GMA: Bisphenol A diglycidylmethacrylate, Bis-EMA: Bisphenol A polyethylene glycol diether dimetacrylate.

sides with a polyester strip (KerrHawe, Bioggio, Switzerland) [9].

Each mold with the uncured composite was hand-held firmly between two microscopic glass slides (1 mm thick), lightly pressed together to remove excess material. An axial load of 500 g was positioned on the top of microscopic glass slide for 30 sec to extrude the material excess, voids and enabling to standardize the thickness of the specimens with parallel and flat surfaces [10].

All specimens were light-cured from both sides by exposure 10 sec to a VALO LED light curing unit (Ultradent, USA). The lamp output was continuously screened during the study by means of a radiometer (Bluephase Meter II, Ivoclar Vivadent), obtaining irradiance values not less than 1000 mW/cm^2 [11]. To eliminate any operator variability, all fabrication finishing and polishing steps of composite specimens were accomplished by the same operator [12].

Specimens Finishing and Polishing

The cured composite specimens were finished and polished with aluminum-oxide abrasive disks (Sof-Lex Pop-On, 3M ESPE, USA), using a series of grit ranging from medium to superfine at a low-speed, utilizing a circular motion in accordance with manufacturer's instructions [1]. A new abrasive disc was utilized after five specimens. A digital caliper (500-151-30, Mitutoyo, Tokyo, Japan) was utilized to verify the dimensions of each specimen [13]. Thereafter, base-line readings of the color and surface gloss were measured [4].

Aging of Specimens

After base-line readings of color and gloss were performed, the specimens were artificially aged in

an accelerated aging tester (Ci35 Weather-Ometer; Atlas Electronic Devices Co, Chicago, Illinois). The specimens were exposed to a 0.55 W/m^2/nm computed at 340 nm utilizing regulated irradiance xenon arc filtered via borate borosilicate glass. The aging cycles included: temperature of the dry bulb was 47°C (light) and 38°C (dark), humidity was 50% (light) and 95% (dark), black panel temperature was 70°C (light) and 38°C (dark), and water temperature was 50°C. The test cycle in the aging chamber included 40 min of light, 20 min of light plus front water spray, 60 min of light, and 60 min of dark plus back water spray. Color and gloss stability of specimens were evaluated for different periods of 100, 200 and 300 total hours of accelerated aging [14,15].

Color Measurements

The color of specimens was assessed by using a spectrophotometer (CrystalEye M639001, Olympus Corp., Tokyo, Japan) **(Fig. 1)** [13]. Five color analysis readings were recorded for each specimen and the arithmetic average of the values were counted. The Standard Commission International de L'Eclairage CIE-Lab color system was utilized for analyzing the color space of each specimen. The L* value measures darkness or lightness (from 0 to 100), the a* value indicates redness (+a*) or greenness (-a*) and the b* value represents yellowness (+b*) or blueness (-b*), respectively [9]. The color change (ΔE*) was counted utilizing Hunter's equation, $\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$ [4,16,17].

Gloss Measurements

The gloss measurements were carried out utilizing a glossmeter [ZGM 1120, Zehntner GmbH Testing Instruments, Switzerland) **(Fig. 2)**, set at a 60° angle of incidence and reflection. A black opaque plastic cover was positioned above the specimens during the measurements in order to avoid the effect of the ambient light and keep the accurate location of the specimens for the repeated measurements. Four readings per specimen were recorded at 60° light incidence and reflection angles, which were averaged to compute an individual value for each specimen [4]. Gloss readings were expressed in gloss units (GU) [7]. Then, the gathered data was tabulated and statistically analyzed after performing color and gloss measurements.

RESULTS

Parametric data was presented as mean and standard deviation (SD) values. Repeated measures ANOVA test was used to study the effect of composite type, aging time and their interactions on the different variables. Bonferroni's post-hoc test

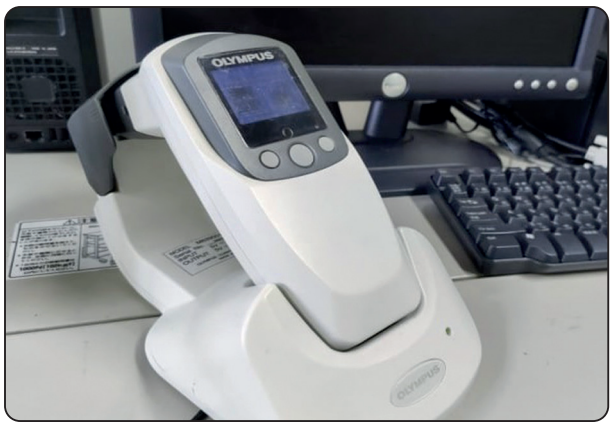

Fig. (1): Photograph of CrystalEye spectrophotometer

Fig. (2): Photograph of Zehntner glossmeter

was used for pair-wise comparisons when ANOVA test is significant. Pearson's correlation coefficient was used to determine the correlation between color change and gloss. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

Color Change (ΔE*)

Composite type (regardless of aging time) had a statistically significant effect on mean ΔE* (P-value <0.001, Effect size = 0.997). Aging time (regardless of composite type) also had a statistically significant effect on mean ΔE* (P-value <0.001, Effect size = 0.997). The interaction between the two variables had a statistically significant effect on mean ΔE* (P-value <0.001, Effect size = 0.942). Since the interaction between the variables is statistically significant, so they are dependent upon each other **(Table 2)**.

Effect of composite type regardless of aging time

There was no statistically significant difference between ST and FZ; both showed the statistically significantly highest mean ΔE* (2.46, 2.40, respectively). OC showed statistically significantly lower mean ΔE* (1.68). FU showed the statistically significantly lowest mean ΔE* (1.46).

Effect of aging time regardless of composite type

There was a statistically significant increase in mean ΔE* after 100 hours (1.09), from 100 to 200 hours (2.12) as well as 200 to 300 hours (2.78).

Effect of different interactions on ΔE*

After 100, 200 as well as 300 hours; there was no statistically significant difference between ST and FZ; both showed the statistically significantly highest mean ΔE*. OC showed statistically significantly lower mean ΔE*. FU showed the statistically significantly lowest mean ΔE*.

Surface Gloss

Composite type (regardless of aging time) had a statistically significant effect on mean gloss (P-value <0.001, Effect size = 0.851). Aging time (regardless of composite type) also had a statistically significant effect on mean gloss (P-value <0.001, Effect size = 0.95). The interaction between the two variables had a statistically significant effect on mean gloss (P-value = 0.004, Effect size = 0.195). Since the interaction between the variables is statistically significant, so they are dependent upon each other **(Table 3)**.

TABLE (2): The mean, standard deviation (SD) values and results of repeated measures ANOVA test for comparison between ΔE* values with different interactions of variables

Time	OC		FU		ST		FZ		*P*-value (Between types)	Effect size *(Partial eta squared)*
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
100 hours	0.92 ^{BG}	0.04	0.69 ^{CG}	0.02	1.42 ^{AG}	0.05	1.33 ^{AG}	0.04	<0.001*	0.986
200 hours	1.86 ^{BF}	0.04	1.63 ^{CF}	0.03	2.55 ^{AF}	0.04	2.45 ^{AF}	0.05	<0.001*	0.99
300 hours	2.24 ^{BE}	0.03	2.05 ^{CE}	0.05	3.41 ^{AE}	0.06	3.4 ^{AE}	0.07	<0.001*	0.993
P-value (Between times)	<0.001*		<0.001*		<0.001*		<0.001*			
Effect size *(Partial eta squared)*	0.991		0.991		0.995		0.996			

: Significant at P ≤ 0.05, A, B, C, D superscripts in the same row indicate statistically significantly difference between composite types while E, F, G superscripts in the same column indicate statistically significantly change by aging time

Effect of composite type regardless of aging time

OC showed the statistically significantly highest mean gloss (85.4 GU). FU showed statistically significantly lower mean gloss (81.2 GU) followed by FZ (75 GU). ST showed the statistically significantly lowest mean gloss (69.2 GU).

Effect of aging time regardless of composite type

There was a statistically significant decrease in mean gloss after 100 hours (83.3 GU), from 100 to 200 hours (73.5 GU) as well as 200 to 300 hours (65.7 GU).

Effect of different interactions on gloss

At base-line, after 100, 200 as well as 300 hours; OC showed the statistically significantly highest mean gloss. FU showed statistically significantly lower mean gloss followed by FZ. ST showed the statistically significantly lowest mean gloss.

Correlation between Color Change (ΔE*) and Surface Gloss (GU)

There was a statistically significant inverse (negative) correlation between color change (ΔE*) and gloss (GU) whether after 100, 200 as well as 300 hours **(Fig. 3)**. An increase in color change is associated with a decrease in gloss and vice versa.

TABLE (3): The mean, standard deviation (SD) values and results of repeated measures ANOVA test for comparison between gloss values with different interactions of variables

Time	OC		FU		ST		FZ		*P*-value (Between types)	Effect size *(Partial eta squared)*
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Base-line	95.4 ^{AE}	2.5	91.1 ^{BE}	2.6	80.3 ^{DE}	2.5	85.9 ^{CE}	3.3	<0.001*	0.826
100 hours	90.3 ^{AF}	1.8	85.3 ^{BF}	4.9	75.9 ^{DF}	3	81.8 ^{CF}	4.4	<0.001*	0.687
200 hours	81.9 ^{AG}	2.9	77.7 ^{BG}	3.2	65.1 ^{DG}	2.4	69.3 ^{CG}	4.8	<0.001*	0.806
300 hours	73.8 ^{AH}	4.1	70.7 ^{BH}	3.1	55.4 ^{DH}	2.3	62.9 ^{CH}	4.8	<0.001*	0.805
P-value (Between times)	<0.001*		<0.001*		<0.001*		<0.001*			
Effect size *(Partial eta squared)*	0.906		0.895		0.927		0.906			

****: Significant at P ≤ 0.05, A, B, C, D superscripts in the same row indicate statistically significantly difference between composite types while E, F, G, H superscripts in the same column indicate statistically significantly change by aging time***

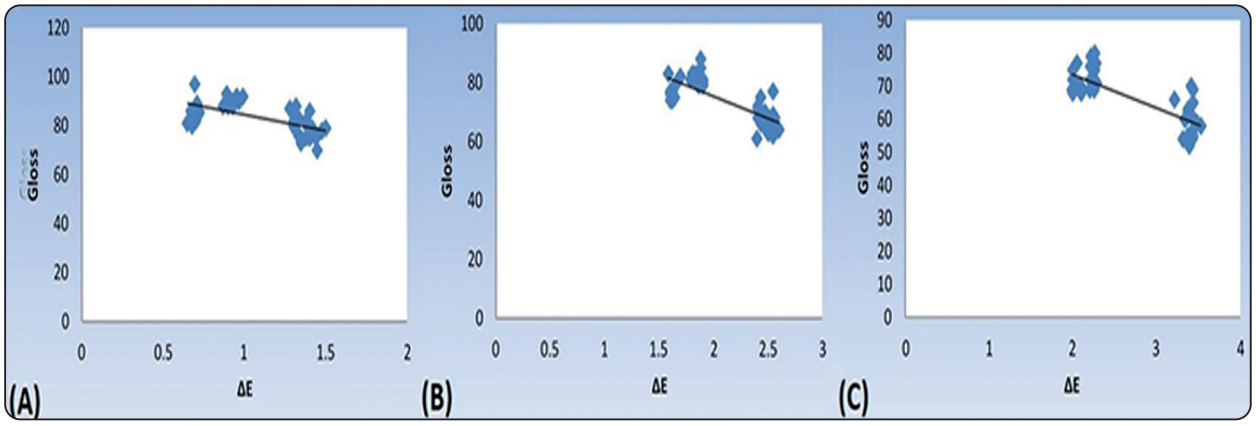

Fig. (3): Scatter diagram representing inverse correlation between ΔE* and gloss (A) after 100 hours, (B) after 200 hours and (C) after 300 hours

DISCUSSION

Dental restorative materials must resist a wide range of circumstances during clinical service, including temperature variations, continual moisture exposure and masticatory stresses. Controlled clinical studies are required to prove the efficacy of treatment methods. However, they are costly and time-consuming. In-vitro testing is an affordable procedure that may be used before clinical research to determine the performance of a novel restorative material [15].

For this in-vitro study, two nanohybrid composites i.e. (Omnichroma, TPH Spectra ST) and two nanofilled composites i.e. (Filtek Universal Composite, Filtek Z350 XT) were used to evaluate their color and gloss stability at different periods of (100, 200 and 300 total hours) of accelerated aging in a weathering device. According to the manufacturer, 300 hours of weathering process equals 12 months of clinical variations in an oral cavity with great caution. Weathering is a suitable method to test the behaviour of dental materials. It includes different cycles of darkness and light exposure with an intermittent water spray [5,18,19,20].

The null-hypotheses were rejected since all restorative materials showed changes in both color and gloss over time after artificial accelerated aging. OC and FU showed better overall color and gloss stability as compared to the other tested composites.

Transparent matrices, such as a polyester strip, which was selected in the present study for creating composites and providing the smoothest highest gloss composite surfaces, on the other hand, will leave a resin-rich surface layer that is easily abraded in the oral environment, exposing inorganic filler materials and accelerates discoloration. To prevent wear and discoloration on the resin-rich surface, polishing is essential to remove the outermost resin. The Sof-Lex polishing system was chosen because it produces the best polishing results while providing conditions that are more similar to clinical reality [21].

Shade A2 displays one of the most prevalent human teeth color in both the young males and females that widely utilized in clinical practice. Thus, in the current study, it was chosen for all examined resin composites except for Omnichroma, which has only one universal shade [17].

The same photo-polymerization protocol was utilized in this research in order to achieve standardization, indicating equal irradiance to all restorative materials, which was done in accordance with the manufacturers' instructions, who have recommended a light curing time of 10 sec when using LED light curing unit with a light intensity equal to or above 1000mW/cm^2 to properly polymerize composite of thickness 2 mm [22,23,24,25].

Color Change (ΔE*)

The color stability of resin composite is considered the primarily requested feature that affects its clinical durability. Clinically visible discoloration is widely recognized as a major cause for the esthetic failure of composite fillings, which necessitates replacement of dental filling materials [13].

ΔE* values less than 1 were identified as unnoticeable by human visual system, and hence only instrumentally recognizable, ΔE* values between 1 and 3.3 were identified visually noticeable by expert observers but still clinically acceptable, while ΔE* values higher than the threshold value of ΔE* = 3.3 were identified noticeable by untrained observer, and hence clinically unacceptable [6].

After 100, 200 and 300 hours of artificial accelerated aging, FU showed the statistically significantly lowest mean ΔE* followed by OC **(Table 2)**. Because their ΔE* values did not surpass the clinical limit value (ΔE* = 3.3), they were clinically acceptable.

Because the restorative materials were not subjected to any discoloring agents, the physico-chemical changes that occurred were caused by internal processes, which primarily affect the resin matrix, photo-initiator system and degree of cure [5,26,27]. Moreover, during the artificial accelerated aging process, the specimens were artificially aged in a water container to keep them hydrated during the light exposure, the absorption of water by resin composite, which is affected by the hydrophobic of the resin matrix causes weakened the link between the fillers and the resin matrix or even hydrolytic degradation of the fillers, which may also contribute to the different extents of color and gloss instabilities [5,26].

Compared to Bis-GMA and TEGDMA monomers present in the resin matrix of ST and FZ composites investigated in this research, the resin matrix of FU is primarily made up of UDMA, which has lower water sorption and solubility as well as higher degree of polymerization and flexibility make better cross linkage [2,28]. Similar to FU, OC is primarily made up of UDMA but it also has the hydrophilic monomer TEGDMA in its composition [2,13,29,30].

These results were in accordance with a recent study by Sulaiman et al. [31] who determined the color and translucency stability of present-day resin-based restorative materials after aging in various storage solutions or thermocycled for 14 days. In comparison to Estilite Quick, which has similar supra-nano fillers and hydrophilic TEGDMA monomer found in OC, which used in this study, FU has the least color change as well as the least change in its translucency. The authors explained the better performance of the FU might be related to its base UDMA monomer.

On the contrary, Cao et al. [32] found Gradia Direct X, which primarily composed of the hydrophobic monomer UDMA was the most color change compared to the hydrophilic monomers TEDGMA and Bis-GMA found in Premisa and Précis. This contradictory can be explained due to difference in chemical composition and filler content; Gradia Direct X, which the authors utilized in their study, is a microhybrid with smaller filler content than the nanofilled FU used in this investigation. As a result, the monomer alone cannot determine the staining degree in composite materials.

After 100, 200 and 300 hours of artificial accelerated aging, there was no statistically significant difference between ST and FZ; both showed the statistically significantly highest mean ΔE* **(Table 2)**. Because their ΔE* values surpassed the clinical limit value (ΔE* = 3.3), they were visually perceptible as well as clinically unacceptable.

The hydrophilicity of ST and FZ could have contributed to these high ΔE* values. Although ST has urethane modified Bis-GMA, which is less hydrophilic than ordinary Bis-GMA [33], it also contains the hydrophilic monomer TEDGMA [31]. While the resin system of FZ contains the hydrophobic UDMA, it may be more prone to water degradation due to its UDMA monomer presents in a small amount. According to manufacturers, it has roughly 10% of UDMA in its composition, and also the presence of the hydrophilic Bis-GMA and TEGDMA monomers [4]. According to previous study by Rahim et al., [34] although FZ comprises zirconia and silica nanoclusters, these clusters of nanofillers may increase the surface area exposed to water, particularly at the interface between the filler particles and the organic matrix, which provide a pathway for water molecules to diffuse into the polymer [35].

Surface Gloss

The gloss of the restoration has a major influence on the longevity of tooth-colored fillings since it can affect color matching and perception. As a result of the random light scattering caused by rough surfaces, the decreased gloss has a detrimental impact on the

appearance of the composite materials, generating mismatch between the restored and the neighboring tooth [4].

According to the incidence of light on the composite surface, the surface gloss values fluctuate [36]. With a 60º measurement angle, a bad surface finish is defined as values below 60 GU, an acceptable finish is defined as values between 60 and 70 GU, a good finish is defined as values between 70 and 80 GU and an exceptional finish is defined as values over 80 GU [37].

At base-line and after 100, 200 and 300 hours of artificial accelerated aging, OC showed the statistically significantly highest mean gloss followed by FU, which showed statistically significantly lower mean gloss followed by FZ **(Table 3)**. All of the restorative materials examined in the current study achieved "an exceptional" gloss at the base-line, but after 300 hours of artificial accelerated aging, OC and FU produced "a good" gloss; and FZ produced "an acceptable" gloss.

These results could be attributed to the surface characteristics of the materials tested. Similar finishing and polishing procedures were utilized for all the types of tested composites to confirm that the discrepancies in surface gloss levels after artificial accelerated aging were due solely to variances in the composite's compositions [26].

Decreased surface gloss due to artificial accelerated aging was related to the surface abrasion of the examined resin composites, which causes a loss of cohesion between filler particles resulting in the formation of surface porosities and micro-cracks that susceptible to plaque accumulation, increase roughness and risk for secondary caries [5,27].

OC has high filler content with the smallest filler size among tested restorative materials. Higher filler content should protect the resin matrix from intense erosion during polishing, resulting in smoother surfaces [37]. Moreover, increased filler content in OC reduces water uptake [30]. Furthermore, the filler morphology has a control over surface gloss. The supra-nano filled composite "OC" has spherical filler morphology with a particle size of 260 nm [11], which generated using the sol-gel process that adjusts the diameter of the fillers while also alters their refractive index [22]. Therefore, OC may reflect the light regularly with lesser diffusion/absorbance than other tested composites [38].

At base-line and after 100, 200 and 300 hours of artificial accelerated aging, ST showed the statistically significantly lowest mean gloss **(Table 3)**. It produced "a bad" gloss after 300 hours of artificial accelerated aging. This can be explained by the fact that, this material is a nanohybrid, consisting of micrometer particles 15 μm and very small nanometer particles of 5 nm. Because this material has bigger micrometer particles, fillers may protrude or detach from the surface layer during polishing, resulting in surface imperfections and flaws [39]. Water particles may also infiltrate inside the polymeric network throughout the degradation process, occupying the microspaces between the chains and facilitating the separating of the siloxane bond and softening of the organic matrix. The reflection of light is compromised if hydrolytic degradation happens [4,40].

Effect of aging time on Color Change (ΔE*) and Surface Gloss

There was a statistically significant increase in mean (ΔE*) by aging time and decrease in mean surface gloss by aging time **(Fig. 3)**. This inverse relation was previously reported by Furuse et al., [26] and Sensi et al., [30] who indicated a physical surface modification occurred after exposing restorative materials to artificial accelerated aging resulting in a change of the refractive index of resin composite proving the influence of artificial accelerated aging on color and gloss stability.

This research, like previous in-vitro investigations, has certain limitations. The oral cavity is constantly subjected to dynamic stresses,

mastication wear, and pH changes caused by various meals and beverages. As a result, further research is needed to assess color and gloss stability in such dynamic settings utilizing larger sample size and longer observation interval [16]. In addition, from a geometrical standpoint, the discs utilized do not entirely resemble a restoration [17].

CONCLUSIONS

Within the limitations of this in-vitro study, the following statements can be drawn:

For the composite materials used in this study, considering all the tested properties, OC and FU displayed excellent color and gloss stability; in contrast, ST and FZ were the most affected by artificial accelerated aging, exhibiting the greatest increase in color and decrease in gloss. A significant negative correlation was found between color and gloss parameters of resin-composite materials investigated, indicating that the better stability of the color of resin composites, the higher of the gloss values.

The filler amount, particle size and type are the most important elements that determine the final characteristics of the resin composite, and this has a direct impact on the resin restoration's durability and lifespan. As a result, these are the characteristics that may be extremely beneficial in controlling the resin composite's behavior to the specific clinical needs.

REFERENCES

1. Korkut B, Türkmen C. Longevity of direct diastema closure and recontouring restorations with resin composites in maxillary anterior teeth: A 4-year clinical evaluation. J Esthet Restor Dent. 2020; 33(4): 590-604. https://doi.org/10.1111/jerd.12697
2. Perdigão J, Araujo E, Ramos RQ, Gomes G, Pizzolotto L. Adhesive dentistry: Current concepts and clinical considerations. J Esthet Restor Dent. 2021; 33(1): 51-68 . https://doi.org/10.1111/jerd.12692
3. Iyer RS, Babani VR, Yaman P, Dennison J. Color match using instrumental and visual methods for single, group, and multi-shade composite resins. J Esthet Restor Dent. 2021; 33(2): 394-400 . https://doi.org/10.1111/jerd.12621
4. Ozera EH, Pascon FM, Correr AB, et al. Color stability and gloss of esthetic restorative materials after chemical challenges. Braz Dent J. 2019; 30 (1): 52-57 . https://doi.org/10.1590/0103-6440201902263
5. Taşın S, Celik G, İsmatullaev A, Usumez A. The effect of artificial accelerated aging on the color stability, microhardness, and surface roughness of different dental laminate veneer materials. J Esthet Restor Dent. 2020: 1-7. https://doi.org/10.1111/jerd.12567
6. Habib ANEDA, Abdelmoniem SA, Mahmoud SA. Effect of children's drinks on color stability of different dental composites: An in vitro study. J Clin Pediatr Dent. 2017; 41 (2): 120-125 . https://doi.org/10.17796/1053-4628-41.2.120
7. Soliman HA, Elkholany NR, Hamama HH, El-Sharkawy FM, Mahmoud SH, Comisi JC. Effect of different polishing systems on the surface roughness and gloss of novel nanohybrid resin composites. Eur J Dent. 2020; 15(2): 259-265. https://doi.org/10.1055/s-0040-1718477
8. Lemon DJ, Chen W, Smith T, et al. The effect of simulated field storage conditions on dental restorative materials for military field use. Mil Med. 2020; 8;185(5-6): e831-e838 . https://doi.org/10.1093/milmed/usz425
9. Strazzi-Sahyon H, Rocha E, Assunção W, dos Santos P. Influence of light-curing intensity on color stability and microhardness of composite resins. Int J Periodontics Restorative Dent. 2020; 40(1): 129-134. https://doi.org/10.11607/prd.4437
10. Lins FCR, Ferreira RC, Silveira RR, Pereira CNB, Moreira AN, Magalhães CS. Surface roughness, microhardness, and microleakage of a Silorane-based composite resin after immediate or delayed finishing/polishing. Int J Dent. 2016: 8346782. http://dx.doi.org/10.1155/2016/8346782
11. Pereira Sanchez N, Powers JM, Paravina RD, Instrumental and visual evaluation of the color adjustment potential of resin composites. J Esthet Restor Dent. 2019; 31 (5): 465-470 . https://doi.org/10.1111/jerd.12488
12. Tavangar M, Bagheri R, Kwon TY, Mese A, Manton DJ. Influence of beverages and surface roughness on the color change of resin composites. J Investig Clin Dent. 2018; 9(3): e12333. https://doi.org/10.1111/jicd.12333

13. Arai Y, Kurokawa H, Takamizawa T, et al. Evaluation of structural coloration of experimental flowable resin composites. J Esthet Restor Dent. 2020: 284-293 . https://doi.org/10.1111/jerd.12674

14. Lee JS, Suh KW, Ryu JJ. The color stability of aesthetic restorative materials resulting from accelerated aging. J Korean Acad Prosthodont. 2008; 46(6): 577-585.

15. Korkmaz Ceyhan Y, Ontiveros JC, Powers JM, Paravina RD. Accelerated aging effects on color and translucency of flowable composites. J Esthet Restor Dent. 2014; 26(4): 272-278. https://doi.org/10.1111/jerd.12093.

16. Moon DJ, Seon EM, Son S, Jung KH, Kwon YH, Park JK, Effect of immersion into solutions at various pH on the color stability of composite resins with different shades. Restor Dent Endod. 2015; 40 (4): 270-275 . http://dx.doi.org/10.5395/rde.2015.40.4.270

17. Bahbishi N, Mzain W, Badeeb B, Nassar HM. Color stability and micro-hardness of bulk-fill composite materials after exposure to common beverages. Mater. 2020; 13(3): 787 . https://doi.org/10.3390/ma13030787

18. Brooksbank A, Owens BM, Phebus JG, Blen BJ, Wasson W. Surface sealant effect on the color stability of a composite resin following ultraviolet light artificial aging. Oper Dent. 2019; 44(3): 322-330 . https://doi.org/10.2341/18-053-L

19. Tuncdemir, A. R., & Güven, M. E. Effects of fibers on color and translucency changes of bulk-fill and anterior composites after accelerated aging. BioMed Res Int. 2018 . https://doi.org/10.1155/2018/2908696.

20. Paravina RD, Ontiveros JC, Powers JM. Accelerated aging effects on color and translucency of bleaching-shade composites. J Esthet Restor Dent. 2004; 16(2): 117-126 . https://doi.org/10.1111/j.1708-8240.2004.tb00018.x

21. Alagha E, Alotaibi W, Maghrbil M, Hakami L, Alrashedi M. Effect of different finishing and polishing techniques on surface roughness of two universal nanohybrid composite resins. Maced J Med Sci. 2020; 8(D): 182-188 . https://doi.org/10.3889/oamjms.2020.4926

22. Tokuyama technical report: OMNICHROMA—Every shade, one choice. Encinitas, CA; Tokuyama; 2019. Available Online: https://omnichroma.com/us/wp-content/uploads/sites/4/2019/01/OMNI-Tech-Report-Color-Final.pdf

23. 3M technical report: Filtek Universal Restorative—Technical product profile. 3M Oral Care; St. Paul; MN; USA; 2020. Available Online: https://multimedia.3m.com/mws/media/1651107O/3m-filtek-universal-restorative-technical-product-profile.pdf

24. Dentsply TPH Spectra ST:—Directions for use for TPH Spectra ST and TPH Spectra ST Effects. Dentsply Sirona Inc., York; Pennsylvania; USA; 2017. Available Online: https://assets.dentsplysirona.com/flagship/en/explore/restorative/tph_spectra_st/TPH%20Specctra%20ST%20%2B%20Effects_MV03_Web_F.pdf

25. 3M Technical Report: Filtek Z350 XT—Technical Product Profile. 3M Oral Care; St. Paul; MN; USA; 2010. Available Online: https://multimedia.3m.com/mws/media/631547O/filtek-z350-xt-technical-product-profile.pdf

26. Furuse AY, Gordon K, Rodrigues FP, Silikas N, Watts DC, Color-stability and gloss-retention of Silorane and dimethacrylate composites with accelerated aging. J Dent. 2008; 36(11): 945-952. https://doi.org/10.1016/j.jdent.2008.08.001

27. M Chen, J-Z Li, Q-L Zuo, C Liu, H Jiang, M-Q Du. Accelerated aging effects on color, microhardness and microstructure of ICON resin infiltration. Eur Rev Med Pharmacol Sci. 2019 Sep;23(18):7722-7731. https://doi.org/10.26355/eurrev_201909_18981

28. Par M, Spanovic N, Tauböck TT, Attin T, Tarle Z, Degree of conversion of experimental resin composites containing bioactive glass 45S5: The effect of post-cure heating. Sci Rep. 2019; 9(1): 17245 . https://doi.org/10.1038/s41598-019-54035-y

29. de Abreu JLB, Sampaio CS, Benalcázar Jalkh EB, Hirata R. Analysis of the color matching of universal resin composites in anterior restorations. J Esthet Restor Dent. 2020; 33(2): 269-276. https://doi.org/10.1111/jerd.12659

30. Sensi L, Winkler C, Geraldeli S. Accelerated aging effects on color stability of potentially color adjusting resin-based composites. Oper Dent. 2021; 46(2): 188-196. https://doi.org/10.2341/20-099-L

31. Sulaiman TA, Rodgers B, Suliman AA, Johnston MW. Color and translucency stability of contemporary resin-based restorative materials. J Esthet Restor Dent. 2020; 33(6): 899-905. https://doi.org/10.1111/jerd.12640

32. Cao L, Huang L, Wu M, Wei H, Zhao S. Effects of cold light bleaching on the color stability of composite resins. Int J Clin Exp Med. 2015; 8(6): 8968-8976. PMID: 26309549; PMCID: PMC4538174

33. Khatri CA, Stansbury JW, Schultheisz CR, Antonucci JM. Synthesis, characterization and evaluation of urethane derivatives of Bis-GMA. Dent Mater. 2003; 19(7): 584-588. https://doi.org/10.1016/S0109-5641(02)00108-2

34. Rahim TN, Mohamad D, Md Akil H, Ab Rahman I. Water sorption characteristics of restorative dental composites immersed in acidic drinks. Dent Mater. 2012; 28(6): e63-e70. https://doi.org/10.1016/j.dental.2012.03.011

35. Poggio C, Ceci M, Beltrami R, Mirando M, Wassim J, Colombo M. Color stability of esthetic restorative materials: A spectrophotometric analysis. Acta Biomater. Odontol. Scand. 2016; 2(1): 95-101. https://doi.org/10.1080/23337931.2016.1217416

36. Andrade KC, Pini NIP, Moda MD, dos Santos PH, Briso ALF, Fagundes TC. Influence of different light-curing units in surface roughness and gloss of resin composites for bleached teeth after challenges. J Mech Behav Biomed Mater. 2020; 102: 103458. https://doi.org/10.1016/j.jmbbm.2019.103458

37. Ereifej NS, Oweis YG, Eliades G. The effect of polishing technique on 3-D surface roughness and gloss of dental restorative resin composites. Oper Dent. 2013; 38(1): E9-E20 . https://doi.org/10.2341/12-122-L

38. Lucena C, Ruiz-López J, Pulgar R, Della Bona A, Pérez MM. Optical behavior of one-shaded resin-based composites. Dent Mater. 2021; 37 (5): 840-848. https://doi.org/10.1016/j.dental.2021.02.011

39. Soliman YA, Mahmoud ELM, Gepreel M.A, Afifi RR. Surface roughness of nanohybrid composites with different monomers after finishing and polishing with different polishing systems. Key Eng Mater. 2020; 835: 41-49. https://doi.org/10.4028/www.scientific.net/kem.835.41

40. Rocha RS, Oliveira AC, Caneppele TMF, Bresciani E. Effect of artificial aging protocols on surface gloss of resin composites. Int J Dent. 2017: 3483171. https://doi.org/10.1155/2017/3483171