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The Effect of Modeling Liquid on Color Stability and Surface Roughness of Single-Shade Composites: A SEM Study

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ABSTRACT

The aim of this study; to evaluate the effects of modeling liquid use on the surface roughness and color change of single-shade universal composite resins. Total 174-cylinder shaped samples (60 roughness, 54 FE-SEM analysis, 60 color measurements) were prepared in 6 groups, (n=10) 3 of only composites, 3 of composites and modeling liquid. Composite samples were stored in coffee for 7 days and then bleached with 35% Total Blanc Office. FE-SEM analysis, color changes and roughness were measured. For statistical analysis, Two-way Anova test were used (p<0,05). There is a statistically significant difference between the groups with and without modeling liquid in terms of roughness and color changes (p<0,05). The highest roughness and color changes findings were observed in Essentia groups for all measurement times. When Essentia modeling is applied with liquid, the decrease in roughness and color changes is insignificant at the baseline, but the decrease is statistically significant after staining and after bleaching. FE-SEM findings show surface changes in single-shade composites after staining and bleaching. The use of modeling liquids affects the surface roughness of single-shade composites. It is also seen that the modeling liquid used on the surface of the composites protects the surface.

Keywords
Bleaching, FE-SEM, Modeling liquid, Universal composite resin.

Introduction
Direct composite restorations are frequently preferred in restorative dentistry for aesthetic complaints about the color and shape of anterior teeth due to the convenient longevity of composite restorations and their low cost compared to indirect restorations [1]. Especially, in recent years, researchers have focused on the use and development of universal composites due to the difficulty of color selection of composites. Resin composites and application techniques that allow the use of simplified application protocols are preferred to shorten chair time and to minimize technical sensitivity. Universal composites can be categorized as group shade or single shade. Single shade composites provide color match with a one shade, while group shade composites match all tooth tones with a few shades [2].

Some of the disadvantages of composite resins are that they stick easily to instruments during use and complicate the reconstruction of the shape and anatomical contour of the restorations. Modeling liquids are used to reduce the surface tension of the composite and facilitate the application of the restoration because of the difficulty of placement and forming procedures [3-6]. To improve the use of resin-based composite materials during restorative procedures, specialty materials often referred to as modeling liquids (MLs), modeling agents, modeling resins, composite lubricants and composite primers have been introduced. These liquids are used to wet dental instruments and brushes and to create a smooth surface. The use of modeling liquids in finishing and polishing procedures shortens the application time.

Modeling liquids are unfilled resins generally composed of methacrylates such as bisphenol A-glycidyl methacrylate (Bis-GMA), urethane dimethacrylate (UDMA), and triethylene

glycol dimethacrylate (TEGDMA). Modeling liquids are mainly composed of hydrophobic resins with little or no organic fillers and ultimately do not affect the structure of the composite [7]. In addition, these resins can reduce the porosities that can be occurred during the layering of composites and can ultimately improve mechanical properties and color stability [3,5,6]. Another important point is that the modeling liquids help to reduce the existing porosities in the composite restoration [3,4]. There are some studies about the effect of modeling liquids on the color stability, surface roughness and microhardness of composites over time, but their effects are not fully known [3,6,8,9]. Color change has been observed in studies examining composite samples stored in staining solutions for a certain period of time [5,6]. In addition, the colors of composite materials can change by bleaching agents and the stained composites may be back to beginning color after bleaching [10]. Acceptable levels of color stability, ensure the baseline microhardness and surface roughness of composites are necessary for clinical success. The increase of surface roughness play an important role in plaque accumulation, marginal integrity and wear behavior of composite restorations. In composite restorations, the rough surface may be stained with liquids such as coffee and tea, causing change of color [4,11].

Over time, many color identification systems and color differences have been proposed for color measurement. Color differences can be measured using the CIELab formula (ΔE*ab) or the recently introduced CIEDE2000 formula (ΔE00) [12] .The CIE L*a*b* color system is one of the most commonly used color systems. The CIE L*a*b* system defines color in three way: L, a and b. The L* axis indicates the degree of lightness, darkness, brightness, or black/white. The benefit of this color system is that it can detect differences of color and interpret them clinically [13]. The magnitude of the color difference is expressed with ΔE, and in its calculation $\Delta E=[(\Delta L^*)^2 +(\Delta a^*)^2+(\Delta b^*)^2]^{1/2}$ formula is used [13]. Calculation of ΔE allows quantification of changes of color because of staining and bleaching procedures [12].

The use of modeling liquids in composite restorations ease the application of composite resins. There are some studies on the optical properties [14-20] and mechanical properties [21,22] of universal composites in the literature, but there are no studies on the use of single-shade universal composites with modeling liquids. In addition, there are studies in the literature with the modeling liquid but using modeling liquids how to affects the composite surface with the application of bleaching has not been studied before.

This study was carried out to assess the effects of low viscosity modeling liquids used with single-shade resin composites on color and surface roughness after staining in coffee solution and bleaching. The first null hypothesis tested, is that modeling liquid was not change the stability of the color of the single-shade universal composites. The second null hypothesis tested is that, modeling liquid was not change the stability of the surface roughness of the single-shade universal composites.

Materials and Methods

Sample Preparation

Three single-shade universal composite resins (Omnichroma, Vittra APS, Essentia Universal,) and a modeling liquid (Signum, Heraeus Kulzer, Hanau, Germany) were selected for this study as shown in Table 1.

Table 1: Materials used in the study.

Material	Composition/ Type	LOT Numbers
Omnichroma (Tokuyama Dental, Tokyo, Japan)	Matrix: UDMA, TEGDMA. Fillers: 79% by weight uniform supra-nano spherical filler (SiO2-ZrO2 260 nm). Nano filled / Single-Shade	LOT: 188M5
Essentia Universal (GC Corporation, Tokyo, Japan)	Matrix: UDMA, Bis-EMA, Bis-GMA, TEGDMA. Fillers: 65% by volume pre-polymerized fillers, barium glass, silica Micro hybrid / Single-Shade	LOT: 2105261
Vittra APS Unique (FGM, Joinville, SC, Brazil)	Matrix: Mixture of methacrylate monomers, UDMA, TEGDMA, photo initiator compound (APS). Fillers: 72-80% by weight, 52-60% by volume boron-aluminum-silicate glass. Nano filled / Single-Shade	LOT: 180321
Signum Liquids (Heraeus Kulzer, Hanau, Germany)	Dimethacrylates, ester multifunctional of methacrylic acid, silane, photoinitiators	LOT: M010718
35% Total Blanc Office (NOVA DFL, Brazil)	Whitening gel: 35% hydrogen peroxide, thickener, plant extracts, amide, sequestering agent, glycol, dye and water. Neutralizer: sodium bicarbonate, preservative and water	LOT: 20110839

APS = advanced polymerization system, Bis-EMA = bisphenol A ethoxylated dimethacrylate, Bis-GMA = bisphenol A-glycidyl methacrylate, TEGDMA = triethylene glycol dimethacrylate, UDMA = urethane dimethacrylate

Total 174-cylinder shaped samples (60 for roughness, 54 for FE-SEM analysis, 60 for color measurements) were prepared in 6 groups (n=10). 10 cylinder-shaped samples (9 mm diameter, 2 mm thickness) were placed into a plexiglass mold for each composite resin groups. For composite samples used modeling liquids, composite was placed into the plexiglass mold then the composite surface was covered with modeling liquid using a brush. Each composite resins were polymerized for 20 s at both the top and bottom surfaces with D- Light Pro (GC, Tokyo, Japan) (Figure 1).

Group 1: Omnichroma composite was placed 2 mm incrementally in a plexiglass mold and polymerized for each surface 10 seconds.

Group 2: Vittra APS Unique composite was placed 2 mm incrementally in a plexiglass mold and polymerized for each surface 10 seconds.

Group 3: Essentia Universal composite was placed 2 mm incrementally in a plexiglass mold and polymerized for each surface 10 seconds.

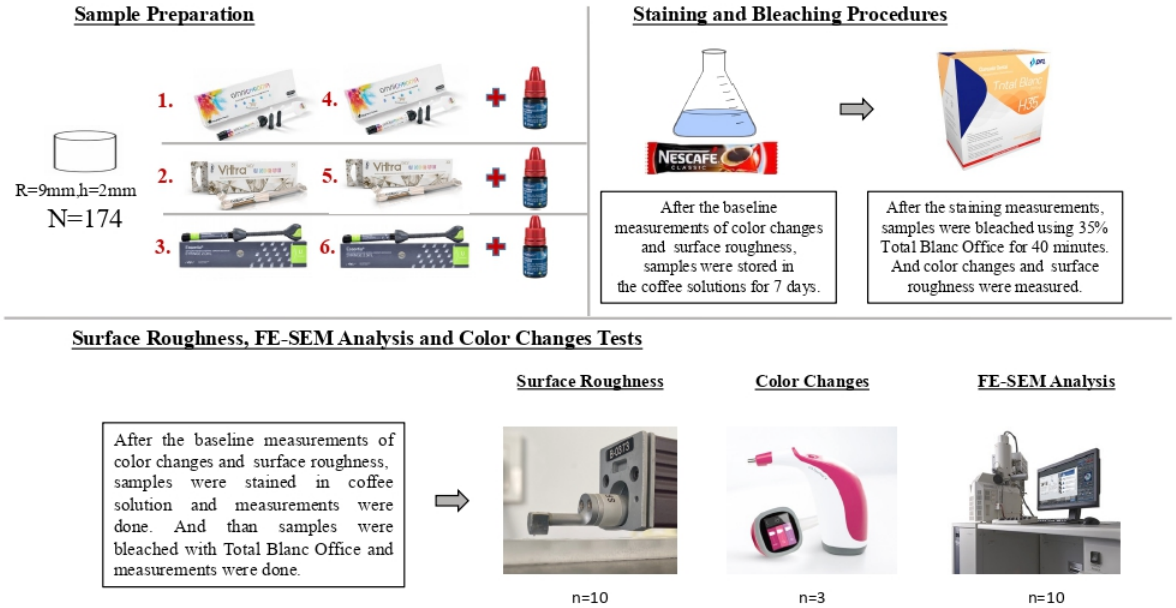


Figure 1. *Flow chart*

Group 4: Omnichroma composite was placed 2 mm incrementally in a plexiglass mold then the composite surface was covered with Signum using a brush and polymerized for each surface 10 seconds.

Group 5: Vittra APS Unique composite was placed 2 mm incrementally in a plexiglass mold then the composite surface was covered with Signum using a brush and polymerized for each surface 10 seconds.

Group 6: Essentia Universal composite was placed 2 mm incrementally in a plexiglass mold then the composite surface was covered with Signum using a brush and polymerized for each surface 10 seconds.

The samples were polished with Super-snap polishing disks (Shofu Inc., Kyoto, Japan) according to manufacturer. Preparations of samples were done by a single operator. The samples were stored in distilled water for 24 h at 37 C° and 100% humidity to allow post-curing [9].

Color Change Measurement

After the preparation of composite samples as previously described, colors of samples were measured using a spectrophotometer (Vita Easyshade) and recorded as CIE L* a* b* values and the device was calibrated after 5 measurements. Measurements were made using a standard white background and under a standard light source. Composite resins color differences are calculated using the formula [1,23]:

$$\Delta E = \sqrt{\left(L_2^* - L_1^*\right)^2 + \left(a_2^* - a_1^*\right)^2 + \left(b_2^* - b_1^*\right)^2}$$

The baseline color measurement of the composite resin samples was tested after 24 hours of storage in distilled water. The clinically acceptable limit of color change was determined as $\Delta E \geq 3.3$ [24]. ΔE1: (baseline-staining), ΔE2: (staining-after bleaching), ΔE3: (baseline-after bleaching)

Surface Roughness Measurement

The values of surface roughness were measured at baseline (T0), staining (T1), after bleaching (T2). To measure the surface roughness value (Ra), a 0.25 mm line scan was made across the surface of the sample using a profilometer (Surftest SJ-301, Mitutoyo, Japan). The profilometer was calibrated with a cut off of 0.25 mm, a reading length of 1.25 mm and a velocity of 0.5mm/s. Three different measurements were obtained at randomly selected three different points from each sample and the average of these three measurements was calculated.

Field Emission Scanning Electron Microscopy (FE-SEM) Analysis

3 samples for each composite group were prepared for FE-SEM analysis (N=54). Composite disc samples were prepared as previously described. All samples were dried in a desiccator for 12 hours and spray coated with gold in a vacuum coating device (LEICA ACE 200). The surface of the samples (baseline, after staining, after bleaching) was assessed under an FE-SEM; (HITACHI SU5000). Photomicrographs of the samples were taken at ×2000 magnification.

Staining Procedures

After the baseline measurements of color and surface roughness had been taken, the samples were immersed in coffee solution (Nescafe Classic, Nestle, Istanbul, Turkey- 20 g of coffee was poured into 1000 ml of boiled distilled water [25]. The samples were stored in the coffee solutions for 7 days [26] and solution was prepared freshly for daily. The lid of the coffee solutions bottle was

quickly closed after use to prevent accidental evaporation. After 7 days of storage, the measurements were performed for all groups as mentioned before.

Bleaching Procedures

After the staining period was completed, the teeth were washed with distilled water, dried and bleaching procedures were applied. The samples were bleached using 35% Total Blanc Office (NOVA DFL, Brazil). The pistons were pushed alternately 6 to 7 times. The bleaching agent was applied over the sample surfaces, left on the surface for 20 minutes, and washed and dried. This procedure was repeated twice, for a total of 40 minutes and color measurements were performed of each sample.

Statistical Analysis

In assessment of the results, IBM SPSS Statistics 22 program was used for statistical analysis. The suitability of the parameters to the normal distribution was evaluated with the Shapiro Wilks and Kolmogorov-Smirnov tests and it was determined that the parameters were suitable for the normal distribution. To evaluate ΔE parameters Two-way Anova test and post hoc Tukey test were used. To evaluate roughness parameters Two-way Anova test and post hoc Tukey test were used. Significance were evaluated $p<0.05$.

Results

Color Change Results

The mean values in color change of composites for different time intervals (baseline, staining and after bleaching) that has been shown in Table 2. Clinically acceptable limit of color change was determined as $\Delta E \geq 3.3$ [24]. While in all composite groups ΔE1, ΔE2 values higher than 3.3, ΔE3 values lower than 3.3. ΔE1, ΔE2 values show a clinically visible color change.

Table 2: Results of Color Change Test of universal composites with or without modeling liquids.

		Omnichroma	Vittra APS Unique	Essentia Universal	
	Signum	**Ort ± SS**	**Ort ± SS**	**Ort ± SS**	**P**
ΔE1	**With Signum**	8.21 ± 1.86^{Aa}	7.84 ± 2.00^{Aa}	11.33 ± 1.11^{Ba}	0.000*
	Without Signum	9.52 ± 1.75^{Aa}	9.11 ± 1.94^{Aa}	15.19 ± 2.74^{Bb}	0.000*
	p	0.124	0.169	0.001*	
ΔE2	**With Signum**	6.30 ± 1.27^{Aa}	5.60 ± 0.90^{Aa}	9.38 ± 1.45^{Ba}	0.000*
	Without Signum	8.06 ± 1.15^{Ab}	6.38 ± 1.14^{Aa}	12.25 ± 2.85^{Bb}	0.000*
	p	0.004*	0.103	0.014*	
ΔE3	**With Signum**	2.30 ± 0.81^{Aa}	1.82 ± 0.49^{Aa}	2.71 ± 0.43^{Ba}	0.010*
	Without Signum	2.55 ± 0.74^{Aa}	1.31 ± 0.48^{Bb}	3.29 ± 0.88^{ABa}	0.000*
	p	0.488	0.031*	0.079	

*Two Way ANOVA Test (*p<0.05)*

Different capital letters in rows indicate the difference between composite groups, different lowercase letters in the columns indicate the difference between signum-non signum.

ΔE1: (baseline-staining), ΔE2: (staining-after bleaching), ΔE3: (baseline-after bleaching)

The baseline-staining color change values (ΔE1) of the composites were analyzed and it was found statistically significant between mean values of ΔE1 among all composite groups, independent of liquid use. The highest change was found in Essentia composite group ($p<0.05$). But when modeling liquid was used, the mean values of color chance was lower than the groups without modeling liquids. The staining-after bleaching color change values (ΔE2) of the composites were analyzed and it was found statistically significant between mean values of ΔE2 among all composite groups, independent of liquid use. The highest change was found in Essentia composite group ($p<0.05$). But when modeling liquid was used, the mean values of color chance was lower than the groups without modeling liquids. The baseline-after bleaching color change values (ΔE3) of the composites were analyzed and it was found statistically significant between mean values of ΔE3 among all composite groups, independent of liquid use. The lowest change was found in the Vittra APS Unique composite group ($p<0.05$) (Figure 2).

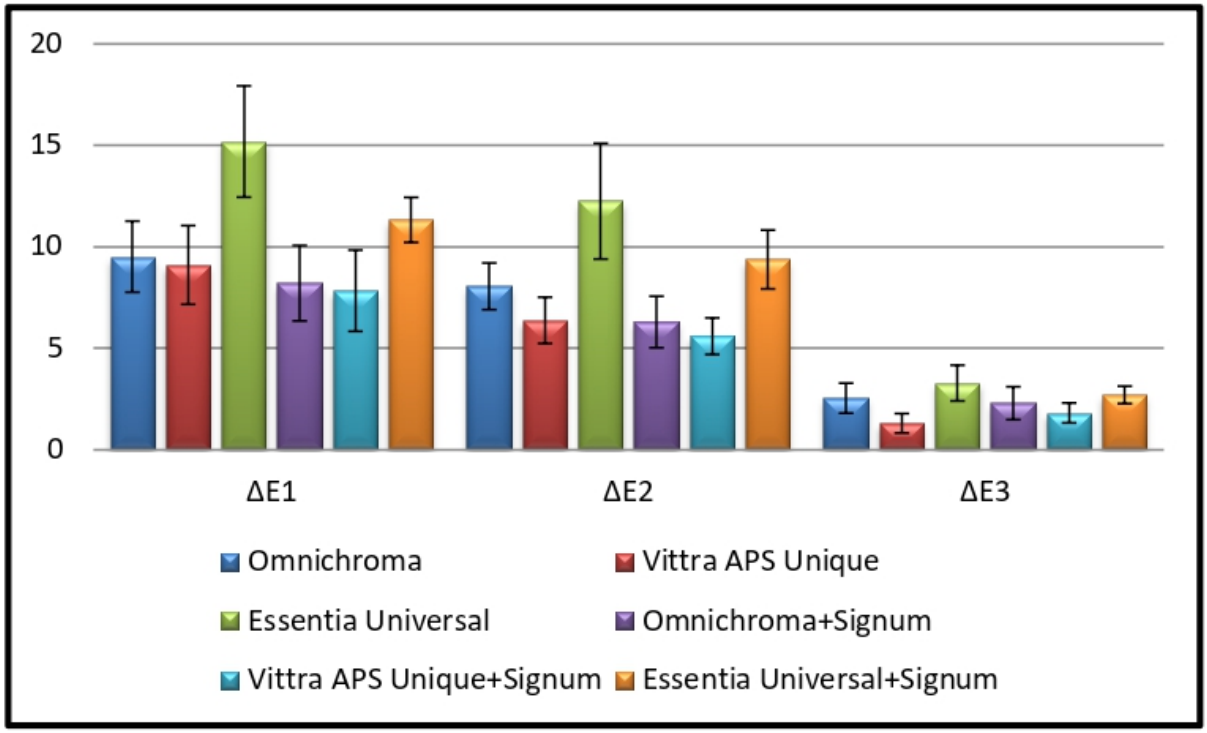
Surface Roughness Results

The results of composite surface roughness for different time intervals (baseline-T0, staining-T1 and after bleaching-T2) that have been shown in Table 3. There was a statistically significant difference between the composite groups in terms of surface roughness ($p<0.05$). There was a statistically significant difference in terms of surface roughness between the groups that applied and not applied modeling liquid ($p<0.05$).

After staining and bleaching, in Omnichroma group significantly difference was found the surface roughness values compared to the baseline. In Omnichroma group and Omnichroma + Signum group, when T0, T1, T2 are compared, the surface roughness after staining was not significantly different compared to the baseline, but surface roughness after bleaching was significant ($p=0.009$) compared to the baseline. In Vittra APS Unique group and Vittra APS Unique + Signum group, when T0, T1, T2 are compared, the surface roughness after staining ($p=0.013$, $p=0.038$) and after bleaching ($p=0.001$) was significant compared to the baseline. In Essentia group, when T0, T1, T2 are compared, the surface roughness after staining ($p=0.006$) and after bleaching ($p=0.001$) was significant compared to the baseline. In Essentia + Signum group, when T0, T1, T2 are compared, the surface roughness after staining was not significantly different compared to the baseline, but surface roughness after bleaching was significant ($p=0.001$) compared to the baseline (Figure 3).

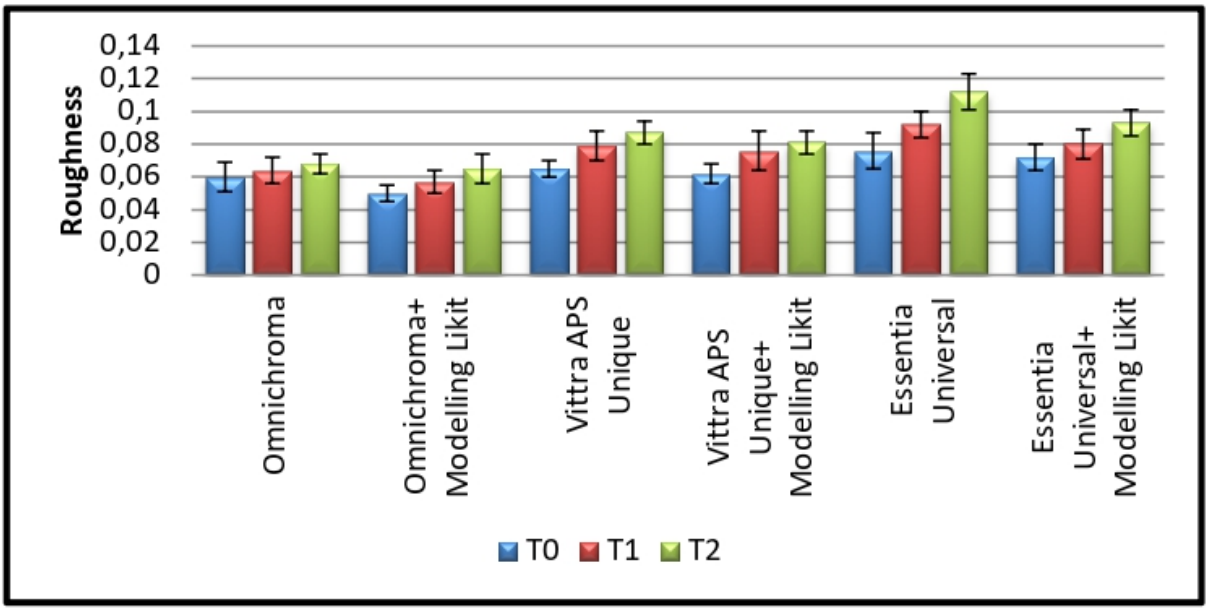
FE-SEM Analysis Results

In the FE-SEM analysis, the most surface changes were observed in Essentia groups. While the porosities observed after staining and after bleaching were higher when the modeling liquid was not applied in all single shade composites, the porosities were relatively reduced when liquid was applied to the surface and in Essentia groups differences were observed more than other single-shade composites. It has been observed that modeling liquid creates a smoother surface in Essentia Universal (figure 4.f1,f2,f3)



ΔE1: (baseline-staining), ΔE2: (staining-after bleaching), ΔE3: (baseline-after bleaching)

Figure 2: the color change results of universal composites with or without modelling liquid with or without modeling liquid.



T0:Baseline, T1:After Staining, T2:After Bleaching

Figure 3: The surface roughness changes of universal composites with or wihout modelling liquid.

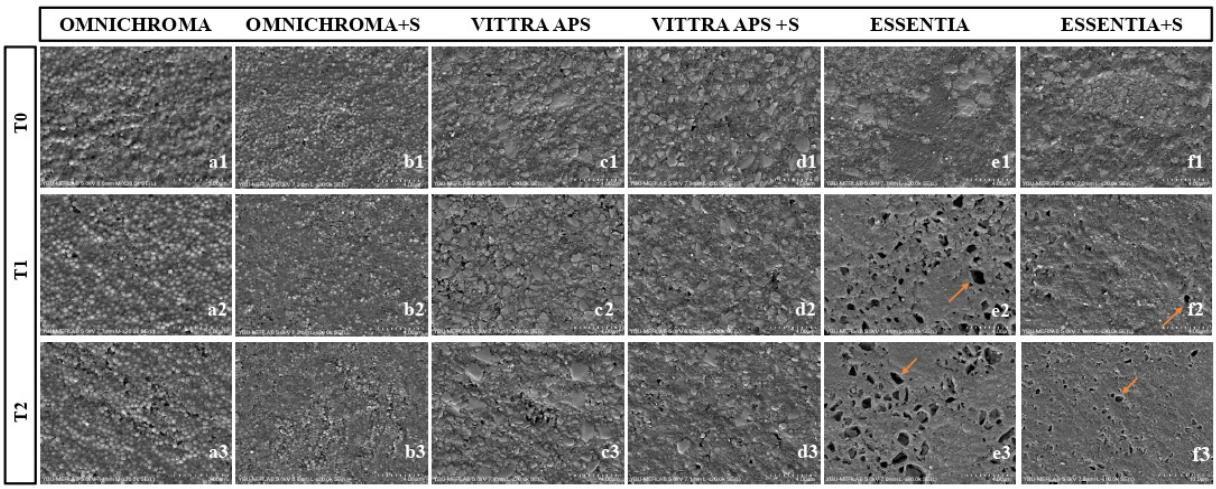


Figure 4: FE-SEM images of universal composites with or without modeling liquid (S: Signum). Figure a,c,e (1,2,3) shows that more surface changes compared the figure b,d,f (1,2,3). When Signum was not applied (figure a,c,e) more and graternumber of porosities formed.

Table 3: Results of Surface Roughness Test of universal composites with or without modeling liquid.

	OM	OM+S	VI	VI+S	ES	ES+S	p value for composite		p value for Signum		
R	**Ort ± SS**	**Ort ± SS**	**Ort ± SS**	**Ort ± SS**	**Ort ± SS**	**Ort ± SS**	**S-**	**S+**	**OM**	**VI**	**ES**
T0	0.060 ± 0.009	0.050 ± 0.005	0.065 ± 0.005	0.062 ± 0.006	0.076 ± 0.011	0.072 ± 0.008	0.001*	0.001*	0.008*	0.264	0.355
T1	0.064 ± 0.008	0.057 ± 0.007	0.079 ± 0.009	0.076 ± 0.012	0.092 ± 0.008	0.080 ± 0.009	0.001*	0.001*	0.055	0.525	0.006*
T2	0.068 ± 0.006	0.065 ± 0.009	0.087 ± 0.007	0.081 ± 0.007	0.112 ± 0.011	0.093 ± 0.008	0.001*	0.001*	0.382	0.074	0.001*
p	**0.014***	**0.007***	**0.001***	**0.001***	**0.001***	**0.003***					
T0-T1 p	1.000	0.075	0.013*	0.038*	0.006*	0.209					
T0-T2 p	0.009*	0.009*	0.001*	0.001*	0.001*	0.001*					
T1-T2 p	1.000	0.312	0.110	0.896	0.005*	0.040*					

*Two-way ANOVA Test (*p<0.05),*
R: Roughness, OM: Omnichroma, VI: Vittra APS Unique, ES: Essentia Universal, S-: Signum not applied, S+: Signum applied, T0: Baseline, T1: After Staining, T2: After Bleaching

composite. In Essentia Universal composite, the volume of the pits formed in the group without modeling liquid (Figure 4.e2,e3) was observed to be larger than the with modeling liquid. In Omnichroma and Vittra APS groups, using modeling liquid (Figure 4.b1, b2,b3,d1,d2,d3) creates a smoother surface, less porosities and pit formation compared without modeling liquid (Figure 4.a1,a2,a3,c1,c2,c3).

Discussion

The clinical use of modeling liquids and universal composites has increased in recent years. The aim of our study is to investigate the effect of modeling liquids on the surface roughness and optical properties of single-shade universal composites. In this study, it was observed that universal composites with and without applied modeling liquid has an effect on surface roughness and color change after storage in coffee and bleaching. Hence, the first and second null hypothesis was rejected. Resin liquids have been used to create smoother surfaces for composites [27,28]. However, it has also been shown that it is difficult to obtain a regular surface in composites with resin-containing liquids [29]. In this study, the surface roughness of these single shade composites were lower in all tested times when the modeling liquid was used and this decrease was statistically significant in Omnichroma at time T0, and Essentia at time T1 and T2 (Table 3).

The highest roughness values were observed in Essentia groups for all three different measurement times. When Essentia is applied with modeling liquid, comparing the without modeling liquid, the decrease in roughness was insignificant at the baseline, but the decrease is statistically significant after staining and after bleaching. The use of Signum modeling liquid has a significant effect on the surface roughness values after staining and after bleaching in Essentia composite. Essentia composite, a microfilled composite, was more affected by staining and bleaching procedures when modeling liquids were not used. The use of liquid created a smoother and more resistant layer on the composite surface. Similar to this finding, in the FE-SEM evaluation, when the modeling liquid was not used, the pits created by staining and bleaching on the surface are formed in larger volumes, while the number and volume of the pits are smaller on the surfaces with modeling liquid (Figure 4. f1,f2,f3). This can be explained by the fact that liquids form a protective layer on the surface against chemical attacks such as coffee staining, vital bleaching. It can be attributed to the fact that the surface is protected owing to the layer

formed on the composite surface with the use of modeling liquid, and that the Essentia composite is less affected by the staining and bleaching procedures owing to the resin-containing layer filled on the microfilled composite surface. More porosities area were observed on the Essentia surface when the modeling liquid was not applied after staining and bleaching. It can also be attributed to its bis-gma content. This could be because the resin composition contains highly soluble monomers including bisphenol A-glycidyl methacrylate (Bis-GMA), bisphenol A-ethoxylated dimethacrylate (Bis-EMA), triethylene glycol dimethacrylate, and urethane dimethacrylate [30]. Increased solution absorption by Bis-GMA and Bis-EMA molecules, which are absent from the organic matrices of Omnichroma and Vittra but present in Essentia, could also be the cause of the low result [31].

Peutzfeldt and Asmussen [32] showed that the fluidity of the composite affects the void formation. For this reason, a more homogeneous and smooth surface formation should be expected on surfaces where modeling liquid is applied. Our surface roughness and FE-SEM findings in this study also support this result. Essentia composite, which shows the highest surface roughness, shows less void formation on its surface when modeling liquid was used comparing without modeling liquids (Figure 4. f1,f2,f3).

Depending on the size of the filler particles separated from the composite surface, it may leave small or large pits on the surface [33]. Single-shade universal composite materials used in this study had different filler sizes; Omnichroma contains spherical particles of 260 nm uniformly spaced and arranged (figure 4.a1), Vittra Unique is a nanoparticle compound with a charge consisting of nanospheres with an average particle size of 200 nm (figure 4.c1), Essentia universal consists of micro hybrid filler particles ranging from 0.85 to 17 µm in diameter (Figure 4.e1). Omnichroma showed the least surface change after staining and after bleaching. Omnichroma particles with a uniform spherical particle size of 260 nm showed less breaking away from the surface causing less roughness. Vittra APS Unique has an advanced polymerization system (APS) for better performance and is less susceptible to chemicals. In this way, it can shows less inorganic particle removal from the surface and less organic tissue softening.

One of the aims of this study is to assess whether the colors of universal composites used with modeling liquids will change at the baseline, staining in coffee and after bleaching. In the literature, there are CIELab and CIEDE2000 formulas among color measurement systems. It can be used in two systems to evaluate the staining of resin composites. In this study, CIELab formula was used to evaluate the color change, supported by the literature [1,23]. As a result of present study alteration in color depends on the use of modeling liquid. Groups with and without modeling liquid showed a color change at all measurement time intervals when stored in coffee and then bleached. These findings suggest that the use of modeling liquid plays a role in the color stability of the universal composite.

The optical properties of composite restorations should not change over time to obtain color stability. The clinically acceptable limit of color change was determined as $\Delta E \geq 3.3$ [24]. In our study, the color changes between the baseline-after staining, after staining-after bleaching were observed to be greater than 3.3, and the color changes between baseline- after bleaching were observed to be less than 3.3. Color changes greater than 3.3 are clinically visible changes, while color changes less than 3.3 are not clinically visible. In our study, color changes was observed in Omnichroma and Vittra APS after staining and after bleaching with or without modeling liquids. The highest and statistically significant staining was observed in the Essentia groups. Significantly less staining was observed when modeling liquids were used with Essentia composite compairing without modeling liquids. This shows that the liquid layer protects the surface from staining. The most color changes was observed in the Essentia group between after staining and after bleaching. In the Essentia group, the most color change was observed without modeling liquid. Color change measurement between baseline and after bleaching was lower than 3.3 for all groups. This shows a color difference that cannot be detected clinically in all composite groups, a samples color close to the initial colors of composites. Omnichroma and Essentia groups composites have turned into a color close to the initial color with or without modeling liquid, but when liquids are used, the color difference was insignificantly lower. Tuncer et al. reported that using or not using modeling liquid did not cause color change on microhybrid composites after staining [4].

Pereira et al. [34], subjected composite samples (Filtek Z250 XT) prepared by using a modeling resin (Modeling Resin, Bisco) to red wine staining and brushing cycles. They evaluated the color and roughness of the samples, and the roughness values increased after brushing cycles regardless of the modeling liquid application. Researchers did not observe any statistical difference in terms of total color changes (ΔE) and color parameters (ΔL, Δa and Δb) of the groups.

In some studies, the effects of bleaching agent on stained composites have been investigated and surface roughness when a bleaching agent is applied to stained composite samples have been investigated in some studies [35-39]. Hubbezoğlu et al. [38] reported that the color change in resin composites did not exceed 3.3 after bleaching with 35% hydrogen peroxide. Likewise, Hafez et al. [35] reported that the in-office bleaching did not show a significant color change on the composite resins. In contrast, Monaghan et al. [39] reported that in-office bleaching significantly affected the optic features of composites, and they observed ΔE values greater than 3.14. Al-Angari et al. [36] compared bleaching agents contained lower concentrations of peroxide with the strips (15% CP vs 10% HP). According to this study, the bleaching agent obtained significant color improvement on all surfaces ($\Delta E > 3.3$) compared with strips. After bleaching, the reported that roughness increased on all surfaces. The bleaching agent significantly increased the roughness compared with the bleaching strips. Researchers claimed this increase can be attributed to the exposure

time. In our study, we observed increased surface roughness on all groups after bleaching, consistent with previous studies. As a result of the bleaching procedures performed after staining, the samples returned to their baseline color and their ΔE values decreased below 3.3.

The final composite layer can be applied with the smoothest surface possible by using a brush that has been soaked with liquids. FE-SEM images (Figure 4) shows that the surface of composite resins is smoother when modeling liquid is applied. In addition, it has been shown that liquid surfaces are less affected by staining and bleaching procedures and less porosity occurred. Sedrez-Porto et al. [1] reported that the positive effect of the liquids may be explained there by to form more stable intermolecular chains with the monomeric structure of the composite. And this situation can prevent the penetration of the molecules causing discoloration on composite surface. These findings are consistent with our study, and it was observed that the liquid applied groups were less affected by the staining and bleaching procedures in surface roughness. In our study, this situation can be explained by the fact that the modeling liquid used creates more stable intermolecular chains with the monomeric structure of the composite. FE-SEM images also support these results. Using modeling liquids, simplifies the polishing procedure of the composite restoration and can reduce the chair time. However, doubts have arisen about the changes in surface roughness and color stability due to the compounds contained in composite restorations over time [1,4]. Composite resins are prone to deterioration due to their polymeric structure, and this deterioration may cause changes in color over time. According to recently published studies [5,6], modeling liquids can be successful in increasing the adaptation between the composite layers and preventing the coloration of the composites. The limitations of this study, clinical conditions could not be fully established in this laboratory study. The aging procedure in a 7-day coffee solution corresponds to less than 1 year of consumption, for these reasons further *in vitro* and *in vivo* studies are required.

Conclusions

1. The use of modeling liquids affects the surface roughness and color changes of single-shade universal composites after coffee staining and office bleaching. The use of modeling liquid on Omnichroma, Vittra APS Unique and Essentia universal composites affected the surface roughness and amount of color change after staining. Within the limitation of this study ıt can be concluded, the use of modeling liquid can enhance the surface features of universal composites.
2. It was seen that the use of modeling liquid maintains the color stability of some single-shade universal composites.
3. In future studies the long-term effects of modelling liquids on the surface features of universal composites could be investigated.

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