Original Article

The Influence of Modeling Liquid on Microhardness of Single-Shade Composite Resins: An *In-Vitro* Study

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ABSTRACT

Aim: To assess the effect of modeling liquid on the microhardness of single-shade universal composites. **Materials and Methods:** A total of 60 disk-shaped samples were prepared in six groups [Omnichroma (OM), Essentia Universal (EU), Vittra APS Unique (VA), OM + Signum, EU + Signum, and VA + Signum] for surface microhardness measurements. Samples were stored in a coffee solution for 7 days and after that bleached with an Office bleaching agent (Total Blanc Office). Surface microhardness was measured for baseline, after staining, and after bleaching. A two-way analysis of variance test was used for statistical analysis ($P < 0.05$). **Results:** In terms of microhardness, there is a statistically significant difference ($P < 0.05$) between the two categories with and without modeling liquid. The alterations in microhardness measurements at baseline, after staining, and after bleaching are statistically significant ($P < 0.05$). The Essentia groups showed the lowest microhardness findings at all measurement times. Microhardness values decreased significantly more when EU was applied along with modeling liquid than when it was not applied at different intervals. **Conclusions:** Modeling liquid affects the microhardness of single-shade composites. Microhardness is reduced when modeling liquid is used for all three single-shade universal composite resins at three different times.

KEYWORDS: *Bleaching, microhardness, staining, universal composites*

INTRODUCTION

Direct composite restorations are more commonly used in clinics to address cosmetic problems with the color and shape of the anterior teeth because they are cheaper than indirect restorations and have an appropriate long life.[1] The esthetic rehabilitation with satisfactory restoration depends on the skill of the clinician, the usage characteristics of the materials, and the physical characteristics of the composite.[2] Some composite resins have a sticky structure and easily stick to the tools used while forming restorations, making it difficult to reconstruct the anatomical contour and shape. Modeling liquids are used to ease the application of the restoration by reducing the surface tension of the composite since the structure of composite resins may prevent placement and shaping procedures.[3-6] These low-viscosity liquids have been reported to be able to penetrate any porosity during the incremental composite placement, helping to reduce defects in the restoration and consequently improve mechanical properties and color stability.[3-6] The use of modeling liquids makes it easier to apply composites and reduces application time.

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Table 1: Chemical composition of the different restorative materials

Material	Type	Composition
Omnichroma (OM) (Tokuyama Dental, Tokyo, Japan)	Nanofilled/ single-shade	Matrix: UDMA, TEGDMA. Fillers: 79% by weight uniform supra-nanospherical filler (SiO_2–ZrO_2 260 nm)
Essentia Universal (EU) (GC Corporation, Tokyo, Japan)	Microhybrid/ single-shade	Matrix: UDMA, Bis-EMA, Bis-GMA, TEGDMA. Fillers: 65% by volume pre-polymerized fillers, barium glass, and silica
Vittra APS unique (VA) (FGM, Joinville, SC, Brasil)	Nanofilled/ single-shade	Matrix: Mixture of methacrylate monomers, UDMA, TEGDMA, and photoinitiator compound (APS). Fillers: 72–80 wt%, 52–60 vol% boron–aluminum–silicate glass
Signum liquids (S) (Heraeus Kulzer, Hanau, Germany)		Dimethacrylates, an ester multifunctional of methacrylic acid, silane, and photoinitiators
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

To minimize treatment time and technique sensitivity, restorative techniques and composite materials that facilitate the use of clinical protocols are preferred. Since color selection may depend on environmental factors and the clinician, the trend toward more accessible shade selection has guided the development of universal composites. Universal composite resins suit the tooth structure because of their blending effect. Group shade composites contain fewer color tones than conventional composites, and single-shade universal composites provide the blending effect using a single tone.[7] Studies investigating the effects of modeling liquids on the group shade and single-shade universal composites are limited.[8,9] In the literature, there are studies on the optical[7,10-15] and mechanical[16,17] characteristics of universal composite resins. Nevertheless, no research studies have been done on the microhardness of single-shade composites with modeling liquids. In addition, it is considered that the microhardness of dental resin-based materials can be changed by bleaching materials,[18] and it has not been investigated how modeling liquids will influence the microhardness of the composite surface with the bleaching procedures. Chemical properties, as well as filler type, shape, and size, may all affect microhardness. A material's filler content affects its mechanical and optical characteristics, including surface hardness, stiffness, color stability, wear resistance, and compressive strength. Additionally, there has been evidence of a positive correlation between surface hardness and filler content. Modeling liquids have lower filler content, and the application of liquids to the surface can create a resin-rich surface layer and affect microhardness.[9] Acceptable microhardness of composites is essential for clinical success. Therefore, this study aims to investigate the influences of modeling liquid used with single-shade universal composites on microhardness in coffee solution (after staining and after bleaching). The microhardness values of single-shade composites will not change as a result of using modeling liquid, according to the null hypothesis.

Materials and Methods

Sample preparation

In this study, Signum modeling liquid (Heraeus Kulzer, Hanau, Germany) (S) and three single-shade composite resins [Omnichroma (OM), Essentia Universal (EU), and Vittra APS Unique (VA)] are used as shown in Table 1.

A total of 60 disk-shaped samples for surface microhardness measurements were prepared in six groups (OM, VA, EU, OM + S, VA + S, and EU + S). For each composite resin group, 10 samples (2 mm thickness and 9 mm diameter-disk-shaped) were prepared into a plexiglass mold. Using a composite brush coated in modeling liquid, the composite resin increments were placed into the plexiglass mold for samples made with low-viscosity modeling liquids. The brush was slightly moistened with modeling liquid and applied to the composite surface. Each composite resin light cured for 20 s at both the bottom and top surfaces with D-Light Pro (GC, Tokyo, Japan). After that, the composite samples were polished for a total of 30 s using Super-snap polishing disks (Shofu, Japan), using fine and super fine settings.

Surface microhardness measurement

Disk-shaped composites were stored for 24 h at 37°C in distilled water before the baseline measurements, and composite samples baseline, after staining, after bleaching surface microhardness values were measured [Figure 1]. A Vicker's diamond indenter was used for the surface microhardness tester (HMV-700 Microhardness Tester, Shimadzu, Japan). Vickers hardness number (VHN, kg/mm^2) was determined for five different locations on each sample using a digital microhardness tester, and the mean VHN was thereby determined from these five measurements by rotating the sample in a clockwise direction around its center. Each sample was measured using a load of 100 gf (980.7 mN) for 10 s for each microhardness test. All hardness values were calculated.

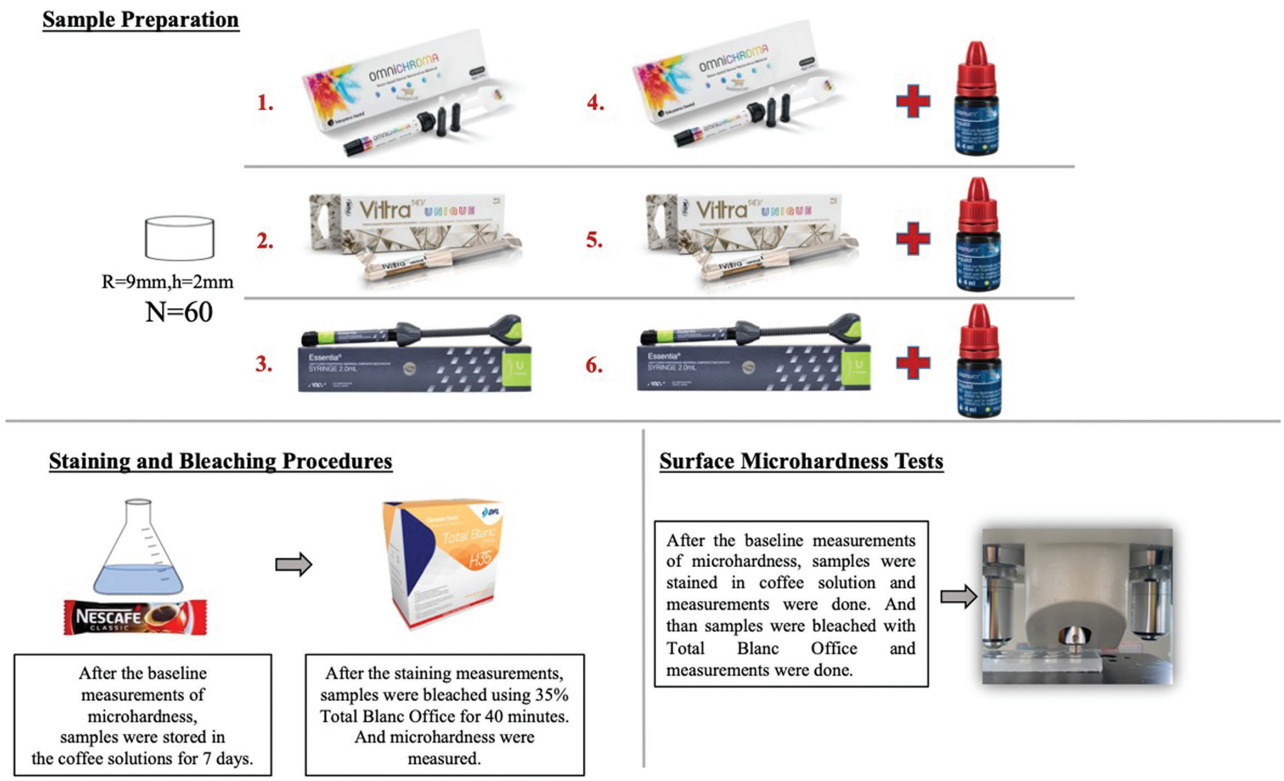

Figure 1: Flow chart

Staining procedures

One liter of boiling distilled water was mixed with 20 g of coffee (Nescafe Classic, Nestle, Turkey) to immerse the samples[19]) after the baseline microhardness and color measurements were evaluated. They were stored in the coffee solution for 7 days,[20] and solutions were changed daily. After 7 days of storage, microhardness was performed on each sample [Figure 1].

Bleaching procedures

After the samples were stained with coffee solution, they were washed with distilled water and dried gently, and 35% of Total Blanc Office (NOVA DFL, Brazil) was used for bleaching [Figure 1]. The product contained peroxide in one syringe and thickener in the other, and the connector was placed in both syringes. The pistons were rotated and pushed six to seven times until a homogeneous yellow color was achieved, indicating that the product was active. The entire mixture was then moved into one of the syringes. After applying the bleaching agent to the sample surface for the first time, it was cleaned and allowed to dry for 20 min. The bleaching procedure was applied again for 20 min and completed for a total of 40 min. The surface microhardness was measured on each sample.

Statistical analysis

In the analysis of study outcomes, statistical analysis was conducted using the Statistical Package for the Social Sciences, version 22 program (IBM Corp., Chicago, IL, USA). The adequacy of parameters for conforming to a normal distribution was assessed through the Shapiro–Wilk and Kolmogorov–Smirnov tests, revealing that the parameters exhibited conformity to a normal distribution. While evaluating the study data, a two-way repeated analysis of variance (ANOVA) test and *post hoc* Bonferroni test was used for microhardness evaluation. The two-way ANOVA test and *post hoc* Tukey honestly significant difference test were used to evaluate the loss of microhardness. Significance was evaluated at the $P < 0.05$ level.

Results

A statistically significant difference in microhardness is evident between groups that applied modeling liquid and those that did not, as well as among various single-shade composite groups ($P = 0.000$ and $P < 0.05$). The alterations in microhardness measurements at baseline, after staining, and after bleaching are statistically significant ($P = 0.000$) [Table 2].

In the OM group, the change in microhardness means at baseline, after staining, and after bleaching was found to be statistically significant ($P = 0.000$ and $P < 0.05$). The decreases that occurred after staining and after bleaching measurements compared with the baseline measurement are statistically significant ($P < 0.05$). The decrease in after-bleaching measurements

Table 2: Vickers hardness numbers values of the composite materials and composite + modeling liquid materials

Microhardness	OM	OM + S	VA	VA + S	EU	EU + S	*P* value for composite		*P* value for modeling liquid		
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	S−	S+	OM	VA	EU
T0	75.30 ± 3.86	67.43 ± 2.36	83.62 ± 3.68	66.21 ± 3.94	60.25 ± 2.81	53.36 ± 3.75	0.000*	0.000*	0.000*	0.000*	0.000*
T1	71.12 ± 2.63	64.95 ± 4.79	77.99 ± 3.69	63.52 ± 3.26	58.03 ± 331	48.23 ± 4.26	0.000*	0.000*	0.002*	0.000*	0.000*
T2	67.88 ± 2.98	62.26 ± 2.74	75.63 ± 3.25	60.45 ± 2.02	57.43 ± 3.00	41.00 ± 1.97	0.000*	0.000*	0.000*	0.000*	0.000*
P	0.000*	0.021*	0.000*	0.001*	0.127	0.000*					
T0–T1 *P*	0.020*	0.332	0.016*	0.421	0.364	0.007*					
T0–T2 *P*	0.004*	0.017*	0.004*	0.005*	0.201	0.000*					
T1–T2 *P*	0.076	0.688	0.348	0.009*	1.000	0.005*					

Two-way repeated measures ANOVA test.

T0 = baseline, T1 = after staining, T2 = after bleaching, OM = Omnichroma, VA = Vittra APS Unique, EU = Essentia Universal, S = Signum, T0–T1 *P* = microhardness difference between baseline and after staining, T0–T2 *P* = microhardness difference between baseline and after bleaching, T1–T2 *P* = difference in microhardness after staining and after bleaching.

*$P < 0.05$

compared with the after-staining measurements was also found to be statistically significant ($P < 0.05$). In the OM and S groups, the change in microhardness means at baseline, after staining, and after bleaching was determined statistically significant ($P = 0.021$ and $P < 0.05$). While there was no significant change after staining measurements compared with the baseline measurement ($P > 0.05$), the decrease was statistically significant after bleaching ($P < 0.05$). There was no statistically significant alteration in after-bleaching measurements compared with after-staining measurements ($P > 0.05$) [Figure 2].

In the VA group, the change in microhardness means at baseline, after staining, and after bleaching was found to be statistically significant ($P = 0.000$ and $P < 0.05$). The decreases that occurred after staining and after bleaching measurements compared with the baseline measurements were statistically significant ($P < 0.05$). There was no statistically significant alteration after bleaching measurements compared with after staining measurements ($P > 0.05$). In the VA and S group, the change in microhardness means at baseline, after staining, and after bleaching was determined statistically significant ($P = 0.001$ and $P < 0.05$). While there was no significant change after staining measurements compared with the baseline measurement ($P > 0.05$), the decrease after bleaching measurements was statistically significant ($P < 0.05$). The decrease after bleaching measurements compared with after staining measurements was also found to be statistically significant ($P < 0.05$) [Figure 2].

In the EU group, no statistically significant change was observed in the microhardness means at baseline, after staining, and after bleaching ($P = 0.127$ and $P > 0.05$). In the EU and S group, the change in microhardness means at baseline, after staining, and after bleaching was found to be statistically significant ($P = 0.000$ and $P < 0.05$). The decreases that occurred after staining and after bleaching measurements compared with the baseline measurements were statistically significant ($P < 0.05$). The decrease after bleaching measurements compared with after staining measurements was also determined statistically significant ($P < 0.05$) [Figure 2].

Discussion

Many commercial forms of composite resins are based on various formulations and contain different components. Because of the different viscosities of resin composites, it is necessary to use specific hand tools or modeling liquids to place composite materials. Using the moistened brush to apply the final composite

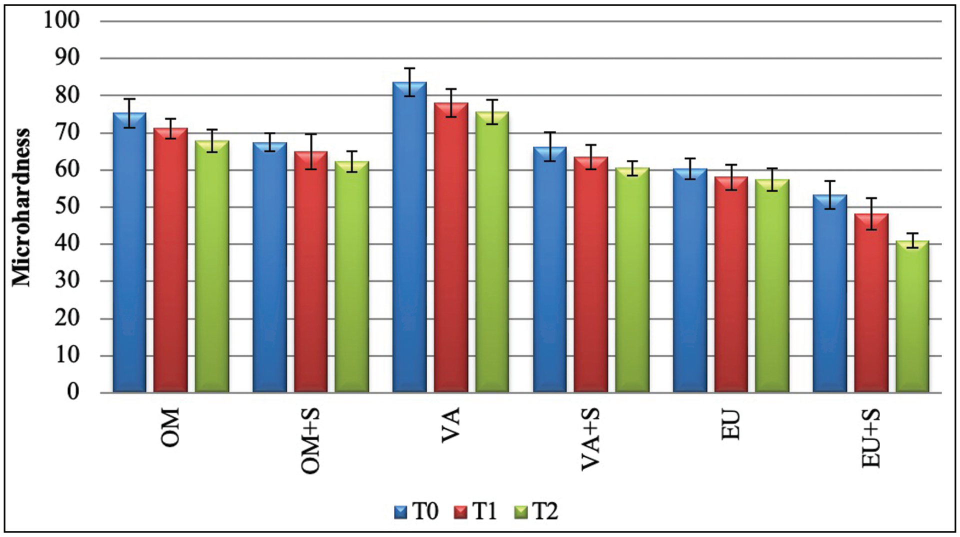

Figure 2: Microhardness values. T0 = baseline, T1 = after staining, T2 = after bleaching, OM = Omnichroma, VA = Vittra APS Unique, EU = Essentia Universal, S = Signum

layer effectively smooths the surface.[8] Nevertheless, concerns have arisen about the changes in restorations of surface microhardness because of the compounds contained in composite resins as time went by.[4] The primary objective of this study was to examine the impact of a low-viscosity modeling liquid on the microhardness of diverse composite materials. In this study, it was found that the storage in coffee influenced the surface microhardness regardless of the application of modeling liquid. Hence, the null hypothesis was rejected.

Microhardness determines the deformation of a material and is often considered a significant parameter for comparison with tooth structure.[21] Although studies correlate the microhardness of composite materials with the degree of conversion when investigated under different polymerization conditions,[22] it is significant to note that the differences in microhardness between different composite resins are not only related to the degree of conversion. Based on the studies in the literature,[23,24] the type of composite resins, composition, size, and filler content of fillers have a significant impact on microhardness values. It has been shown that increased filler loading results in an increase in microhardness values.[25] Likewise, the application of modeling liquid to the surface may have created a resin-rich surface layer and reduced surface microhardness due to the lower filler content of the liquid.

When the modeling liquid (S) was not applied, the mean baseline microhardness of the VA composite was statistically significantly higher than that of OM and EU composites. When S was applied, the mean baseline microhardness of the EU composite was statistically significantly lower than that of OM and VA composites. Both OM and VA composites have a higher filler loading than EU composites. These results agree with the results of Yeh *et al*.[26] who detected that the hardness value of Grandio was higher than Filtek Z350, Premisa, and Estelite Sigma. In our study, the lowest value for baseline microhardness was observed in the EU. Greater filler content can make stronger the composite resins.[27] The microhardness of the EU has the lowest values compared with other composites for all periods. When modeling liquid is applied to the EU, the current microhardness is decreased further. This may be correlated with the percentage of inorganic content. Modeling liquid without filler may have created a greater decrease with the EU, which has a lower filler surface.

In our study, a statistically substantial decrease was observed in the microhardness values for all three times (baseline, after staining, and after bleaching) in the groups to which modeling liquids were applied. It is thought to be because of the filler volume of the modeling liquids. At the surfaces of the universal composite resins, modeling liquids created a rich resin layer. These results agree with the results of previous studies.[4,9] Tuncer *et al*.[4] obtained significantly lower hardness values when composite resin discs with modeling liquids were prepared with polyester matrix strips. The microhardness differences between the groups were found to be between 40% and 80%. Bayraktar *et al*.[9] investigating the effects of modeling resins on the surface microhardness of composites, using six different composite resins and three different modeling agents, and the use of modeling resins in all groups decreased the microhardness values. These findings are compatible with our study but in the study by Kütük *et al*.[28] a microhybrid composite EU and different modeling resins were used, and it was shown that the surface microhardness values were not affected in any way by modeling resins, storage environment, or storage time. These findings are inconsistent with our findings. In comparing the three times (baseline, after staining, and after bleaching), the change in the mean hardness of the composites, at the baseline, after staining, and after bleaching was statistically significant, except for the EU groups. Pereira *et al*.'s study,[29] which used modeling resin (Modeling Resin, Bisco, Schaumburg, IL, USA) on composite specimens (Filtek Z250 XT, St. Paul, MN, USA), involved cycles of brushing and red wine staining, and the red wine staining group was the only group to show a decrease in microhardness when the modeling resin was not applied. Recent research has shown that, while modeling liquids may be effective in improving the adaptability between composite layers and avoiding coloration in composites, it also results in a decrease in surface microhardness.[4,9,29] In a review, Chaves *et al*.[30] reported that the use of modeling liquids did not affect the surface microhardness of the tested composite resins, but although there was no statistical difference between the groups using modeling liquids, liquid surfaces offered a softer surface (three out of four studies included). They attributed this to the modeling liquids" probably contain dimethacrylate monomers with low-viscosity, hydrophilic behavior, and high reactivity properties, and may cause a softening effect on the organic matrix. In their review study, Paolone *et al*.[31] attributed the decrease in microhardness to the presence of a resin-rich layer formed on the surface by modeling liquids, which was removed by finishing and polishing procedures. Therefore, they reported that finishing and polishing procedures have a significant impact on microhardness. They also reported that this finding was supported by Tuncer *et al*.[4] who compared the effect of modeling liquids with or without surface polishing and reported statistically lower microhardness values for unpolished samples.

The absence of artificial saliva in the samples' storage and the possibility that clinical conditions were not precisely replicated are the study's limitations. The other limitation is the storage time (7 days) in coffee corresponds to a consumption of shorter than a year, and in future studies, the results of immersing in coffee solution for a longer period can be evaluated. The third limitation is a single modeling liquid was used; different modeling liquids may have different effects. Therefore, more *in vivo* and *in vitro* studies are needed.

Conclusion

The surface microhardness of single-shade composites is affected by the application of modeling liquids. Microhardness is reduced when modeling liquid is used for all three universal composite resins (OM, VA, and EU) at three different times (baseline, after staining, and after bleaching). It is considered that modeling liquids can reduce the microhardness of composites initially, after staining, and after bleaching as the result of a resin-rich surface layer. Because of this, caution should be used when applying modeling liquids to the surface, and use them only when it is required.

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Conflicts of interest

There are no conflicts of interest.

Author contributions

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Ethical policy and Institutional Review board statement

Not applicable.

Patient declaration of consent

No references from previously published articles were used in the current study.

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No published material (including figures/diagrams, short extracts, or content taken from websites) from previously published articles was used in the current study.

Clinical trial registration

The present study is an *in vitro* study, there is no need for a clinical trial registration number.

Data availability statement

Not applicable.

Abbreviations

OM: Omnichroma
VA: Vittra APS Unique
EU: Essentia Universal
S: Signum modeling liquid
APS: Advanced polymerization system

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