

Original Research Article

Evaluation of the Effect of in-Office Bleaching Agent on Mechanical Properties of Different Single-Shade Resin Composites: An *In-Vitro* Study

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ABSTRACT

Aim: This study aimed to evaluate the surface roughness and micro-hardness of five different single-shade resin composites *in vitro* after a bleaching treatment protocol.

Material and Methods: A total of fifty resin composite specimens were prepared from each single-shade resin composite (Filtek Universal [FU], Vittra Unique [VU], Omnichroma [O], Essentia Universal [EU], Charisma Diamond One [CDO]). Ten specimens were prepared from each material, for surface roughness and micro-hardness testing (n=10). After the first measurements, in-office bleaching gel was applied to the specimen surfaces three times, and each application took 15 minutes. After the bleaching protocol, the measurements were repeated, and the values were statistically analyzed using one-way ANOVA and post-hoc t-tests.

Results: After bleaching, the increase in surface roughness (SR) in the EU group (0.012±0.022 Ra) was statistically significantly higher than in the other groups (p<0.05). The decrease in micro-hardness measured as Vicker's micro-hardness (VMH) value in the VU group (-15.84±9.53 MPa) was significantly higher than the other groups (p<0.05). There was no statistically significant difference between the other groups (p>0.05).

Conclusion: The material that showed the highest increase in roughness after bleaching was EU. It was observed that the office-type bleaching agent caused a decrease in Vicker's micro-hardness value in all materials. In clinical practice, if office-type bleaching agents are to be used, it is important to exercise caution, as they may cause adverse effects on existing restorations particularly by increasing surface roughness and reducing the micro hardness of restorative materials.

Keywords: Composite resins; Hardness; Surface roughness; Tooth bleaching

INTRODUCTION

Currently, resin composites (RCs) are chosen for direct teeth restorations. Dental restorations must have a pleasing aesthetic appearance, including color matching and polishability.¹ The manufacture of RC materials with varied color shades has been stimulated by the fact that real teeth have varying color tones. Frequently, the Vita Classical color guide is used as a reference. Additionally, RCs with varying degrees of opacity (dentin, opaque, body, or translucent) are also offered on the market. These materials are intended to mimic the optical characteristics of dentin and enamel so that they can be employed in various dental structures.² However, dental practitioners currently prefer permanent RC materials and restoration techniques, which allow the application of simplified clinical protocols to minimize technical precision and chair time. The development of materials known as universal RCs has resulted from a tendency toward simplifying color selection because choosing a hue can be challenging and depends on environmental and operator-related factors. In the past, the term "universal RC" was used to refer to the RCs' capacity to be utilized in both posterior and anterior tooth repair. However, this term is used today to describe the ease of tooth color selection because the material has a greater "blending effect" due to its special filler particles.³ Currently, universal RC materials contain suprananoparticles. Manufacturers report that spherical fillers provide opacity by reflecting light (chameleon

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effect) and maintain high gloss retention.⁴ Universal RCs, whether single-shade or group-shade materials, contain fewer shades. As a result, it becomes easier to create restorations that match the color of the tooth tissues with less color.³ As an alternative to group-tone resin composites, which only cover a small color range corresponding to specific VITA classic tones, single-shade resin composites (SSRCs) that can simulate all tones are now available. The improved color adjustment potential of SSRCs, which expresses the interplay between perceptual and physical components, is a benefit.⁵ The shade selection stage is eliminated because the SSRCs match nearly all shades. Through reflections, the RCs' blending effect allows restorative materials to potentially match the surrounding tooth structure's hue. Light scatters in various directions and diffuses over the surface of the filler particles when it strikes the restorative material.⁶ The blended effect of restorative materials has been reported to increase with decreasing restoration size and increasing restorative material translucency.⁷ The blending effect is also commonly referred to as the chameleon effect or color adjustment potential.⁶

Currently, with the increasing popularity of esthetics, tooth bleaching treatments have become one of the most desired esthetic dental treatments by patients.⁸ Teeth bleaching is a very conservative method for treating discolored teeth. Bleaching treatment can be classified as office bleaching and home bleaching according to the application method. Office bleaching is a treatment method that provides direct professional supervision to prevent soft tissue exposure and gel ingestion, shorten treatment time, and provide rapid bleaching.⁹

During the bleaching treatment, reactive oxygen species from the agents may come into contact with the dental restorations existing in the mouth and affect the surface roughness (SR) and micro hardness.^{10,11} This affect varies depending on the matrix structure, polymerization dynamics, filler type, monomer type, and percentage of the resin composite, and the type of bleaching agent.¹²

To simplify the selection of restorative materials in the clinical environment, the structural properties of single-shade universal RCs that can be used in the

restoration of anterior teeth and posterior teeth must be balanced to meet both aesthetic and mechanical requirements.¹³ Some studies examined the impacts of bleaching applications on the mechanical and physical characteristics of RCs. However, the effect of bleaching on SSRCs is an issue that needs to be investigated. This study aimed to assess the surface roughness (SR) and Vicker's micro-hardness (VMH) value of five distinct SSRCs following a bleaching treatment regimen. The null hypotheses of the study were that the SR and VMH values of SSRCs are not affected by the bleaching treatment procedure.

MATERIAL AND METHODS

Table 1 provides the details of the materials used in the research. Figure 1 illustrates the study design.

Specimen Preparation

Sample size calculations based on a Cohen's $d=0.60$, 95% power, and a 5% error level suggested including at least nine specimens in each group. Considering possible data losses, 10 specimens were planned for each group. G*Power (v. 3.1.9.6.; Franz Faul, Universitat Kiel, Germany) package program was used for specimen size calculations for all statistical analyses.

The following five SSRCs were used for this study: Filtek Universal (FU), Vittra Unique (VU), Omnicroma (O), Essentia Universal (EU), and Charisma Diamond One (CDO). Detailed information for the materials is presented in Table 1. A total of 50 specimens were prepared, 10 from each SSRC ($n=10$), for SR and VMH tests. Each material was formed into discs with a thickness of 2 mm and a diameter of 7 mm. A digital micrometer (Mitutoyo America Corporation, Aurora, IL, USA) was used to verify that the thickness of the specimens after finishing/polishing remained within the critical tolerance of 0.01 mm. A plexiglass mold was positioned over a 1 mm thick glass slide and a mylar strip, filled with RC in a single increment, and then the mylar strip and glass slide were placed on the plexiglass mold. The glass slide was subjected to light pressure. This pressure was used to guarantee uniformity in the specimen thickness and spacing from the light curing point, as well as to eliminate any surplus composite material from the mold.

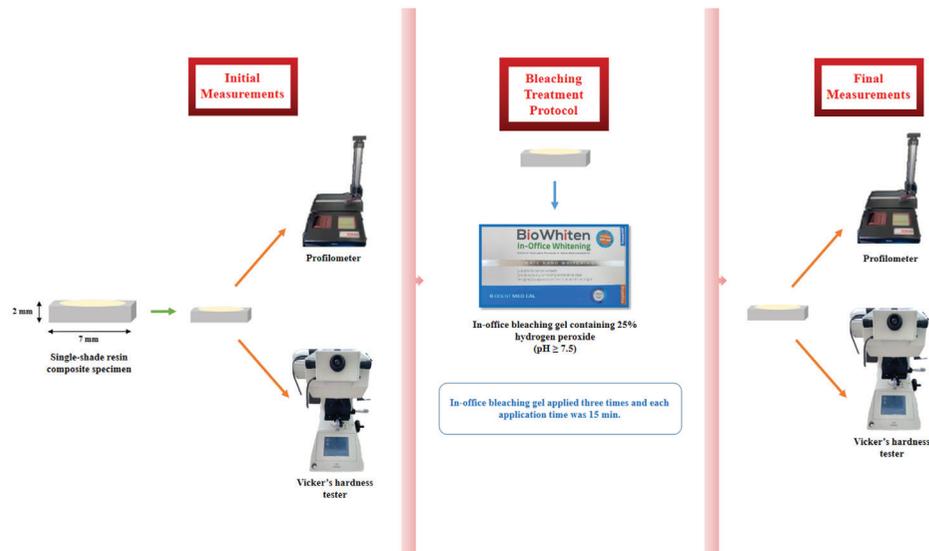


Figure 1. Study design. Surface roughness (SR) was measured with a profilometer and Vicker's Micro-Hardness (VMH) value by Vicker's hardness tester instrument before (T0) and after (T1) bleaching process, all in vitro. The outcome variable was the difference between T1 and T0 values for each of the specimens used.

Table 1. Single-shade resin composites (RCs) tested in this study

Material	Manufacturer	Type	Organic matrix	Inorganic filler	Filler Size	Filler wt/vol
Filtek Universal (FU)	3M ESPE, St. Paul, MN, USA	Nanofill	UDMA, Bis-GMA, PEGDMA, Bis-EMA, TEGDMA	Silica, zirconia	Composed of 20 nm silica, 4-11 nm zirconia, and 100 nm ytterbium trifluoride	76.5/58.4
Vittra Unique (VU)	FGM, Joinville, SC, Brazil	Nanohybrid	UDMA, TEGDMA	Active ingredients: photoinitiator composition (APS), co-initiators, stabilizer and silane. Inactive ingredients: The nanospheres of a complex of silicazirconia	0.2 µm	72–80/60
Omnichroma (O)	Tokuyama, Tokyo, Japan	Supra-nano spherical	UDMA, TEGDMA	260 nm spherical SiO ₂ -ZrO ₂	2.6 µm	79/68
Essentia Universal (EU)	GC Corp., Tokyo, Japan	Microhybrid	UDMA, Bis-EMA, Bis-GMA, Bis-MEPP, TEGDMA	17 µm prepolymerized filler (strontium glass+lanthanoid fluoride) 16 µm silica, 0.85 µm FAISi glass, 16 µm fumed silica	16 µm-16 nm	81/-
Charisma Diamond One (CDO)	Kulzer, Germany	Nanohybrid	TCD-Urethaneacrylate, UDMA, TEGDMA	Barium Aluminium Boro Fluor Silicate Glass	5-20 µm	80/64

Abbreviations: UDMA, Urethane dimetacrylate; Bis-GMA, Bisphenol A diglycidylmethacrylate; PEGDMA, Polyethylene glycol dimethacrylate; Bis-EMA, Bisphenol A polyethylene glycol diether dimetacrylate; TEGDMA, Triethylene glycol dimethacrylate; Bis-MEPP, 2,2-bis 4-methacryloxypolyethoxyphenyl propane; TCD-Urethaneacrylate, Tricyclodecane-Urethaneacrylate; SiO₂, silicon dioxide; ZrO₂, zirconium dioxide; FAISi, fluoroaluminum-silicon.

A light-emitting diode (LED) light curing equipment (D-Light Pro, GC Europe N.V., Leuven, Belgium) was then used to polymerize the RCs in High Power [HP] mode for 20 seconds at an intensity of 1400 mW/cm².¹⁴ Before the initial measurements, the specimens were stored in distilled water at 37°C for 24 h.

Finishing and Polishing Procedure

The specimens were polished using the Clearfil Twist Dia (Kuraray, Japan). To ensure standardization, the

polishing procedure was performed by the same operator. The stages of the finishing and polishing process are as follows: Step 1: The medium grit pre-polishing wheel was applied under dry conditions with light pressure for 30 s with a handpiece speed of 10.000 rpm. The surfaces were then rinsed for 10 s. Step 2: The high-shine fine grit polishing wheel was applied under dry conditions with light pressure for 30 s with a handpiece speed of 10.000 rpm. The surfaces were then rinsed for 10 s⁵ (Table 2).

Table 2. Information on the polishing system and bleaching agent used in this study

Polishing system	Manufacturer	Matrix	Abrasives	Particle size		
Clearfil Twist Dia (two-step)	Kuraray, Japan	Rubber	Diamond particles	Prepolisher		
				Medium grit: 25-35 µm		
				High-shine polisher		
				Fine grit: 4-8 µm		
Product, Manufacturer	Abbreviation	Application Protocol	Total Time	pH Indicated by the Manufacturer	Active Principle (Commercial Presentation)	Ingredients (Technical Profile)
Biowhiten, Biodent Ltd., İstanbul, Türkiye	25% Hydrogen Peroxide with nano-hydroxyapatite	3 applications of 15 min per session	45 min	Alkaline (pH ≥ 7.5)	Hydrogen Peroxide 25% and nano-hydroxyapatite	Water, Glycerin, Alcohol, Sodium bicarbonate, Sodium hydroxide, 25% Hydrogen Peroxide and nano-hydroxyapatite

Bleaching Treatment Protocol

The bleaching treatment procedure was carried out as directed by the manufacturer. An in-office bleaching gel (Biowhiten, Biodent Ltd., İstanbul, Türkiye) with 25% hydrogen peroxide and nanohydroxyapatite (nHA) was applied three times for a total of fifteen minutes each time. After the bleaching treatment, the teeth were washed and dried¹⁵ (Table 2). After every fifteen minutes of application, the bleaching agent on the restoration surface was wiped off with a sterile sponge and then the bleaching agent was reapplied.

SR and VMH measurements of the prepared specimens were performed before (T0) and after (T1) the bleaching treatment protocol.

Measurement of Surface Roughness

Using a profilometer, each specimen's SR was evaluated (Surftest SJ 301-Mitutoyo, Illinois, USA). Arithmetic mean roughness values (Ra) and profilometric profiles were both recorded. Following four measurements with each specimen rotated at an angle of 90°, the mean Ra value for each specimen was reported.

Measurement of Vicker's Micro-Hardness (VMH)

The VMH of the surfaces of the prepared specimens was measured using a Vicker's hardness tester (HMV-700 Micro-hardness Tester, Shimadzu, Japan). During the test, the device was operated by applying a load of 100 g, equivalent to 980.7 mN, for

10 s. The rhombic projection corners formed were then marked under the ocular at ×40 magnification, and Vicker’s hardness was measured. For every specimen, the measurements were repeated four times. The surface VMH was defined as the mean of the measured values.

2.6. Statistical Analysis

The IBM SPSS Statistics 22 application was used for statistical analysis to assess the results. The Shapiro-Wilks test was used to assess the conformance of the data to normal distribution. The one-way ANOVA test was performed as the omnibus test to examine whether there was a statistically significant difference among the groups. A paired sample t-test was used for pairwise comparisons between the groups. The significance level was set at p<0.05.

RESULTS

Surface Roughness Results

There was a statistically significant difference between the groups in terms of roughness values at T0 and T1 (p=0.001, p=0.001, respectively). The roughness (SR) values of the CDO, EU, and VU groups were found to be statistically significantly higher than the FU and O groups at T0 and T1

(p<0.05). There was no statistically significant difference between the other groups (p>0.05) (Table 3). A significant increase in SR values was observed after bleaching in only the EU compared to the initial values (p<0.05). The corresponding values for other groups did not differ statistically significantly from each other (Table 3).

Vicker’s Micro Hardness Results

There was a statistically significant difference between the groups in terms of the VMH means at T0 and T1 time (p=0.001; p<0.05). While the VMH mean of the EU group was found to be statistically significantly lower than all other groups at T0 and T1 (p<0.05), the VMH mean of the CDO group was found to be statistically significantly higher than all other groups (p<0.05) (Table 4). There was a statistically significant difference between the groups regarding the amount of hardness change at T1 compared to T0 (p=0.006; p<0.05). A significant decrease was observed in VMH values after bleaching in all groups compared to the initial values (p<0.05). The amount of VMH decrease at T1 compared to T0 in VU was significantly higher than in the other groups (p<0.05). The changes between the T0 and T1 values in other groups were comparable with each other (p>0.05) (Table 4).

Table 3. Intra-group and inter-group surface roughness (SR) assessments

Surface Roughness (Ra Value)	T0	T1	² p	ΔT
	Mean±Sd	Mean±Sd		Mean±Sd
FU	0.062±0.01 ^a	0.063±0.01 ^a	0.591	0.001±0.006 ^a
VU	0.087±0.02 ^b	0.089±0.02 ^{ab}	0.168	0.002±0.004 ^a
O	0.064±0.01 ^a	0.065±0.01 ^a	0.591	0.001±0.006 ^a
EU	0.089±0.02 ^b	0.101±0.03 ^b	0.111	0.012±0.022 ^b
CDO	0.103±0.03 ^b	0.104±0.03 ^b	0.591	0.001±0.006 ^a
¹ p	0.001*	0.001*		0.029*

¹Oneway ANOVA Test ²Paired samples t test *p<0.05
Different letters in the columns indicate the difference between groups.

Table 4. Intra-group and inter-group Vicker’s micro hardness (VMH) assessments

Vicker’s Micro Hardness (MPa Value)	T0	T1	² p	ΔT
	Mean±Sd	Mean±Sd		Mean±Sd
FU	90.64±4.41 ^a	85±5.57 ^a	0.004*	-5.64±4.73 ^a
VU	98.27±9.47 ^{ab}	82.42±5.18 ^a	0.001*	-15.84±9.53 ^b
O	82.49±4.85 ^a	73.19±4.76 ^b	0.002*	-9.31±6.94 ^a
EU	71.73±5.42 ^c	63.63±2.57 ^c	0.003*	-8.10±6.27 ^a
CDO	111.14±5.02 ^d	104.41±5.54 ^d	0.021*	-6.73±7.66 ^a
¹ p	0.001*	0.001*		0.006*

¹Oneway ANOVA Test ²Paired samples t test *p<0.05
Different letters in the columns indicate the difference between groups.

DISCUSSION

Following the bleaching application, no statistically significant change was observed in the SR values of the RCs except EU. Therefore, the first null hypothesis of the study was partially rejected. Following the bleaching application, a statistically significant decrease was observed in the micro-hardness values of the materials. Therefore, the second null hypothesis of the study was rejected.

It is important from a clinical standpoint to concentrate on the interaction between restorative materials and bleaching agents.¹⁶ Because they are inexpensive and minimally intrusive, RC materials are frequently employed in restorative dentistry for their good aesthetic qualities. It might be difficult for physicians to achieve color and visual harmony between neighboring teeth and RC restorations. Clinicians frequently need to employ layering techniques and numerous RC shades by the VITA Classic Shading System to achieve the best restoration outcomes.^{17,18} The process of choosing colors will become more difficult if several RC shades are used, which will raise expenses and patient chairside time. To solve this problem, SSRCs, which, as long as the manufacturer's recommendations are followed, can match all Vita Classic shades using just one shade with a flawless chameleon effect, have been produced. This makes choosing a shade easier and cuts down on chairside time.¹⁷

Potential bleaching-induced alterations may have a clinically significant impact on dental restorative quality, potentially necessitating replacement. Many bleaching techniques have been employed, each with a unique mode of action. The particular substrate discoloration treated, the bleaching solution and technique used, and the substrate's color affect how well the bleaching process goes. For bleaching at home and in the workplace, the agents currently on the market are often based on peroxide gels in varying concentrations. The way the bleaching agent and the restorative material interact is crucial from clinical importance.¹⁹

The latest trend in RC development focuses on achieving excellent color-matching capabilities using only a single shade of RC without layering. Many manufacturers have produced SSRCs using similar

concepts; however, they have different properties and likely different mechanisms underlying their color matching and blending with the surrounding tooth structure.²⁰ There are various studies in the literature on SSRCs, but these studies generally focus on the optical properties of the materials.^{17,21} Therefore, in this study, the effect of office-type bleaching applications on the SR and VMH of five different single-shade universal RCs on the market was evaluated.

The surface morphology of RCs following finishing processes is impacted by the size and shape of the filler particles. Improved surface smoothness is anticipated when filler particle size is decreased.¹⁶ Bleaching agents, a non-invasive method²² of bleaching teeth that are stained internally or externally, enhance the appearance of natural teeth. Their effects are proportional to the concentration of the bleaching gel and the exposure period; the longer the exposure time, the more pronounced the color change will be, which might increase SR in restorative materials. Surface alterations during bleaching are more likely to occur in RC materials.²³ Bleaching agents have been shown to increase the SR of RCs.²⁴ In this study, the material that showed the highest increase in roughness after bleaching was EU. Among the materials evaluated in the study, EU had the highest average particle size. The high average filler particle size may cause the SR of the material to be high after bleaching application. Altınışık *et al.*⁵ evaluated the effect of polishing SSRCs with different polishing systems on the gloss and SR of the materials. Consequently, in the study, it was confirmed by SEM and AFM images that the surface of EU, which has a microhybrid structure and contains larger prepolymerized filler particles, was rougher than the surfaces of other SSRCs after polishing with different polishing systems. These results support the results of this study. The literature has few investigations evaluating the effect of bleaching agents on EU and VU material. However, the effects of various chemical agents on this material are being evaluated. Kedici-Alp *et al.*²⁵ assessed the effect of food-imitating liquids on the surface properties of single-shade universal RCs. Consequently, the study observed that the material with the highest roughness values after immersion in food-simulating liquids was EU and VU. These

results are consistent with the results of our study. This agreement is expected as EU is a microhybrid structure resin composite consisting of filler particles with diameters ranging from 0.85 to 17 μm , while VU is a nanohybrid composite with a mean particle size of 200 nm.

In this study, it was observed that one of the RCs showing the highest SR values was CDO. Alharbi *et al.*²⁶ evaluated the effect of different finishing and polishing systems on the surface properties of universal SSRs. Consequently, the study reported that CDO showed the highest SR values. These results are also consistent with the results of our study. According to the researchers, this could be because of variations in the shape, size, and kind of filler particles. CDO material contains barium aluminum boron fluoride silicate with a larger particle size of 5 nm-20 μm . Furthermore, because prepolymerized fillers have a poor connection with the polymer matrix, they might pit and create noticeable surface flaws. The structure of these particles in the material may be effective in increasing the roughness on the surface when a bleaching agent is applied to the material. Chen *et al.*²⁷ evaluated the effect of aging and bleaching on the color stability and SR of various RCs, including CDO material. Consequently, the study reported that bleaching significantly increased the SR of all materials. Researchers have reported that hydrogen peroxide can affect bonding agents by breaking carbon-carbon bonds or ester bonds, leading to the displacement of fillers and rougher surfaces. Surface roughness plays a critical role in bacterial adhesion, plaque accumulation, and discoloration. It has been reported that Ra values exceeding 0.2 μm may facilitate biofilm retention and aesthetic deterioration.²⁸ It was observed that the SR of all SSRs evaluated in the study, both at the initial and after bleaching, was below 0.2 μm Ra, which is the acceptable threshold value for this parameter.

VMH tests have been used to determine the strength and mechanical properties of materials. Different methods are used to evaluate the hardness of the surfaces of materials used in dentistry. Vicker's hardness test is the most commonly used test to measure the surface VMH of RCs in dentistry.²⁹ Wear resistance and long-term stability in the oral environment are thought to be directly correlated with Vicker's hardness.³⁰ Therefore, in this study,

Vicker's hardness test was used to analyze the surface hardness of RCs.

One of the most crucial physical characteristics influencing RCs' resilience to wear and scratching is surface VMH.³¹ To put it another way, VMH shows how resistant a material is to wear and plastic deformation. Increased crosslinking via polymerization processes has a major impact on VMH.⁶ Hardness, however, depends on intramolecular interactions and polymer structure, just like other dental resin characteristics. Hardness levels are raised by the presence of urethane bonds and aromatic rings.³² Dental RCs have mean Vicker's Hardness Values (VHN) between 30 and 100. On the other hand, a VHN value of 40-50 is required to replicate normal tooth tissues. The kind, shape, and size of fillers also have an impact on VMH; increased filler content leads to higher hardness.⁶ However, the VMH of RCs depends on factors such as resin matrix content, type and shape of filler particles, and filler particle ratio.²⁹ Material hardness determines the filling's ability to absorb mechanical forces during mastication. If the resin composite's hardness is too low, the material cannot effectively distribute the loads, resulting in excessive surface wear and, consequently, the gradual loss of shape and durability of the restoration.³³ In this study, the material with the greatest decrease in hardness after bleaching was VU (a decrease of approximately 16.1% was observed). Among the materials evaluated in this study, VU was the material with the lowest amount of filler by weight. The fact that VU was the material with the greatest decrease in hardness can be attributed to the fact that it contains the lowest amount of filler by weight.

In this study, a decrease in VMH values was observed after bleaching application in all material groups. These results are consistent with the study by Hannig *et al.*³⁴ and the study by Taher *et al.*³⁵, where carbamide peroxide breaks down into 2/3 urea and 1/3 hydrogen peroxide when in contact with water. Researchers reported that hydrogen peroxide produces free radicals, which cause the polymer chains to separate and the double bonds in the RC structure to break; this may be related to the decrease in surface VMH. Furthermore, free radicals have an impact on the resin-filler contact and cause microcracks to form.³¹

An unavoidable limitation of experimental studies is that it is difficult to replicate all clinical conditions, such as saliva (pH value) and water rinsing, actual patient mouth temperatures, and the effects of brushing with high precision in laboratory studies. Another limitation of the study is that the materials were not subjected to aging. Most importantly, all in-vivo surface changes occur directly through biofilm formation, which cannot occur in experimental tests.¹⁷ Therefore, further clinical and in-vitro studies are needed to confirm the results of this study evaluating to what extent bleaching agents alter the surface and mechanical properties of SSRs. In this perspective, long-term results should be examined.

CONCLUSIONS

Within the limitations of the current study, it was concluded that:

- The material that showed the highest increase in roughness after bleaching was EU.
- It was observed that the office-type bleaching agent caused a decrease in micro-hardness in all materials.
- It should be considered that office-type bleaching agents applied in the clinic may cause changes in the mechanical properties of restorative materials such as SR and VMH.

CONFLICTS OF INTEREST STATEMENT

The authors report no conflicts of interest to declare.

Ofis-Tipi Ağartma Ajanının Farklı Tek-Renk Rezin Kompozitlerin Yüzey ve Mekanik Özellikleri Üzerindeki Etkisinin Değerlendirilmesi: Bir *in-vitro* Çalışma

ÖZET

Amaç: Bu çalışmanın amacı, ağartma tedavi protokolünden sonra beş farklı tek-renk rezin kompozitin yüzey pürüzlülüğünü ve mikro sertliğini in-vitro olarak değerlendirmektir.

Gereç ve Yöntem: Her tek-renk rezin kompozit materyalden,

yüzey pürüzlülüğü ve mikro sertlik testi için onar örnek olmak üzere (Filtek Universal [FU], Vittra Unique [VU], Omnichroma [O], Essentia Universal [EU], Charisma Diamond One [CDO]) toplam elli rezin kompozit örneği hazırlandı (n=10). Başlangıç ölçümlerinden sonra, örnek yüzeylerine üç kez ofis-tipi ağartma jeli uygulandı ve her uygulama süresi 15 dakikaydı. Ağartma protokolünden sonra, ölçümler tekrarlandı ve değerler tek yönlü ANOVA ve post hoc t-testi kullanılarak istatistiksel olarak analiz edildi ($p<0.05$).

Bulgular: EU grubunda (0.012 ± 0.022 Ra) pürüzlülükteki artış miktarı diğer gruplardan anlamlı derecede daha yüksekti ($p<0.05$). VU grubunda (-15.84 ± 9.53 MPa) Vicker's mikro sertlik (VMH) değerindeki azalma miktarı diğer gruplardan anlamlı derecede daha yüksekti ($p<0.05$). Diğer gruplar arasında istatistiksel olarak anlamlı bir fark yoktu ($p>0.05$).

Sonuç: Ağartma sonrası pürüzlülükte en fazla artış gösteren materyal EU oldu. Ofis-tipi ağartma ajanının tüm materyallerde mikro sertlikte azalmaya neden olduğu gözlemlendi. Klinik uygulamada, ofis-tipi ağartma ajanları kullanılacaksa, mevcut restorasyonlar üzerinde özellikle restoratif materyallerin yüzey pürüzlülüğünü artırarak ve mikro sertliğini azaltarak olumsuz etkilere neden olabileceklerinden dikkatli olunması önemlidir.

Anahtar Kelimeler: Diş ağartma; Kompozit rezinler; Sertlik; Yüzey pürüzlülüğü;

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