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Effect of Applying Mouthwashes with an Oral Irrigator on Surface Roughness of Nanohybrid Resin Composites

Ağız Gargaralarının Ağız Duşu ile Uygulanmasının Nanohibrit Kompozitlerin Yüzey Pürüzlülüğü Üzerine Etkisi

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ABSTRACT

Objectives: This study aimed to evaluate the effects of different mouthwashes, applied either directly or via an oral irrigator, on the surface roughness of stained nanohybrid single-shade resin composites.
Materials and Methods: Two hundred disk-shaped specimens (8×2 mm) were prepared from two nanohybrid single-shade resin composites (Charisma Diamond One and Vittra APS Unique). All specimens were immersed in a coffee solution (3 g/50 mL) for 12 days to simulate one year of staining. Half of the specimens were treated with direct mouthwash immersion for 12 hours, while the other half were exposed to mouthwash solutions delivered using an oral irrigator for 40 seconds. Each method included subgroups (n=10) treated with distilled water, Sensodyne Pronamel, Listerine Fresh Burst, Colgate Plax White+Charcoal, and Crest 3D White. Surface roughness (Ra, µm) was measured using a profilometer at baseline, after staining, and following mouthwash application. Data were analyzed at $p<0,05$ level by using Robust ANOVA and Bonferroni post-hoc tests ($\alpha=0.05$).
Results: Coffee staining significantly increased surface roughness compared to baseline ($p<0.001$). Mouthwash applications reduced roughness compared to the stained condition, but values remained above baseline ($p<0.05$). No significant difference was found between the application methods ($p>0.05$). All mouthwashes produced similar surface roughness changes ($p>0.05$).
Conclusions: Colored beverages increase the surface roughness of nanohybrid single-shade resin composites used in this study. Mouthwashes reduced roughness in stained specimens but did not restore surfaces to original smoothness. Oral irrigator use did not significantly affect the outcome compared to direct application. Mouthwash and dietary habits should be considered in restorative material selection.
Keywords: Oral irrigator, mouthwash, surface roughness, nanohybrid resin composite, profilometer.

ÖZ

Amaç: Bu çalışmada farklı ağız gargaralarının, ağız duşu kullanılarak veya doğrudan uygulanmasının, renklendirilmiş nanohibrit tek renkli rezin kompozitlerin yüzey pürüzlülüğü üzerindeki etkilerinin incelenmesi amaçlanmıştır.
Gereç ve Yöntemler: İki ayrı nanohibrit tek rezin renkli kompozitten (Charisma Diamond One ve Vittra APS Unique) 8×2 mm boyutlarında toplam 200 adet disk şeklinde örnek hazırlandı. Örneklerin kahve solüsyonunda (3 g/50 mL, 12 gün) bekletilerek bir yıllık kullanıma denk renklendirme yapıldı. Örneklerin yarısına ağız gargaraları doğrudan; diğerlerine ağız duşu aracılığıyla uygulandı. Her grupta distile su, Sensodyne Pronamel, Listerine Fresh Burst, Colgate Plax White+Charcoal ve Crest 3D White gargaralarından oluşan 5 alt grup oluşturuldu (n=40). Doğrudan ağız gargarası uygulanacak örnekler ilgili solüsyonda 12 saat bekletildi. Kalan örneklere ağız duşu haznesine konan solüsyonlar 40 sn süreyle uygulandı. Başlangıç, renklendirme sonrası ve gargara uygulanması sonrası yüzey pürüzlülüğü bir profilometre (Ra, µm) ile ölçüldü. Veriler $p<0,05$ anlamlılık düzeyinde Robust ANOVA ve Bonferroni çoklu karşılaştırmaları ile değerlendirildi ($\alpha=0,05$).
Bulgular: Kahve ile renklendirmeden sonra tüm örneklerin yüzey pürüzlülüğünde başlangıca kıyasla anlamlı ölçüde arttırdı ($p<0,001$). Gargara uygulamaları sonrası pürüzlülük değerleri renklendirme sonrasına göre azaldı ancak başlangıç değerlerinin üzerinde kaldı ($p<0,05$). Ağız duşu ile uygulama ile doğrudan uygulama arasında nihai yüzey pürüzlülüğü açısından istatistiksel fark bulunmadı ($p>0,05$). Farklı gargara solüsyonlarında benzer yüzey pürüzlülüğü değişimleri gözlendi ($p>0,05$).
Sonuç: Renkli içecekler bu in vitro çalışmada kullanılan her iki nanohibrit rezin kompozitin yüzey pürüzlülüğü değerlerinde başlangıca kıyasla anlamlı ölçüde artış gözlendi ($p<0,001$). Ağız gargaraları renkli yüzeylerin pürüzlülük değerlerini iyileştirse de nihai pürüzlülük değerlerinde artışı engelleyememiştir. Ağız duşu kullanımı, gargara solüsyonlarının yüzey pürüzlülüğü üzerindeki etkisini doğrudan uygulamaya kıyasla anlamlı derecede değiştirmemiştir. Restoratif materyal seçiminde renkli içecek ve günlük kullanılan ağız gargaralarına maruziyet göz önünde bulundurulmalıdır.
Anahtar Kelimeler: Ağız duşu, ağız gargarası, yüzey pürüzlülüğü, nanohibrit rezin kompozit, profilometre.

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INTRODUCTION

Resin composites are widely used in restorative dentistry due to their aesthetic and mechanical advantages. Recently, single-shade universal nanohybrid composites have been developed to simplify shade selection by matching a wide range of tooth colors with one material (Cruz da Silva et al., 2023). These composites utilize optical blending capabilities, known as the “chameleon effect,” to mimic surrounding tooth structure (Islam et al., 2023). Manufacturers incorporate specialized fillers and monomers to enhance color adjustment and translucency (Korkut et al., 2023; Zhu et al., 2023). Although some studies report higher discoloration over time compared to multi-shade composites, these changes often remain clinically acceptable (Tepe et al., 2025). Current research continues to evaluate their properties such as hardness, gloss, and roughness (Atalay et al., 2023).

Apart from color, the surface quality of composite restorations is essential for clinical success. A smooth surface enhances aesthetics and reduces plaque accumulation and staining (Gehlot et al., 2022). Surface roughness, often quantified as Ra, is measured by profilometry per ISO standards, with contact profilometers preferred for their precision (Lucena et al., 2021). Surfaces rougher than 0.2 µm are more prone to biofilm adhesion and discoloration. Surface texture is influenced by both intrinsic factors (e.g., filler size, matrix bonding, resin hardness) and extrinsic ones (e.g., polishing technique, oral exposure) (Chowdhury et al., 2023; Yilmaz & Mujdeci, 2021). Proper finishing can achieve Ra values of ~0.1 µm, particularly in nanohybrid composites (Zhang et al., 2021). Polymerization parameters such as light intensity, duration, and wavelength also affect surface characteristics. Inadequate curing may leave an oxygen-inhibited layer and unreacted monomers, leading to a softer and rougher surface more vulnerable to degradation (Sarialioglu Gungor et al., 2023; Yilmaz Atalı et al., 2022). Higher degrees of conversion are associated with smoother, more durable surfaces, emphasizing the need for optimized light-curing protocols (Duratbegović et al., 2024).

Oral irrigators (water flossers) are increasingly used in oral hygiene as they deliver pressurized fluid to remove plaque and debris from interdental and subgingival areas. They support periodontal health by reducing gingival inflammation and bleeding (Altalhi et al., 2023). However, their impact on restorative materials remains underexplored. Compared to studies on toothbrushing or mouth rinses, limited research has assessed how oral irrigators affect composite surfaces. Existing studies have examined variables like solution type and pressure settings, with inconsistent results—some reporting increased surface roughness, while others found no significant effect (Alharbi et al., 2020; Alavi et al., 2022; Alavi et al., 2023). These conflicting outcomes highlight the need for further investigation, particularly under conditions simulating both mechanical and chemical stress.

The present study investigates the effects of different mouthwashes, applied either directly or using an oral irrigator, on the surface roughness of single-shade nanohybrid resin composites. By analyzing changes in surface texture under simulated oral conditions, this research aims to provide evidence-based guidance for optimizing restorative material performance and maintaining surface integrity.

The null hypotheses of the study were as follows:

1. There is no statistically significant difference in surface roughness values among different nanohybrid resin composites exposed to the same mouthwash.
2. There is no statistically significant difference in surface roughness values of nanohybrid resin composites treated with different mouthwashes.
3. There is no statistically significant difference in surface roughness values between direct immersion and oral irrigator application methods.

MATERIALS AND METHODS

Two single-shade nanohybride resin composite materials from different manufacturers were used in this study: Charisma Diamond One (Kulzer, Germany), Vittra APS Unique (FGM, Brazil). The details of these composites, including brand names, manufacturers, monomer compositions, filler types, filler loadings, and lot numbers, are provided in Table 1.

Table 1. The brand names, manufacturers, monomer compositions, filler types, filler loadings, and lot numbers of the single-shade universal resin composites.

Composite Material	Abbreviation	Manufacturer	Type	Monomer Composition	Filler Composition / Size	Filler % (W/V)	Lot Number
Charisma Diamond One	DO	Kulzer, Germany	Nanohybrid	UDMA, TCD-DI-HEA, TEGDMA	B_2O_3-F-Al_2O_3-SiO_2, silica, TiO_2, fluorescent and metallic oxides, organic pigments (5–20 µm)	81 / 64	N010209
Vittra APS Unique	VU	FGM, Brazil	Nanohybrid	UDMA, TEGDMA	Zirconia and silica fillers (200 nm)	82 / 72	230921

Abbreviations: TEGDMA = triethylene glycol Di methacrylate; UDMA = urethane dimethacrylate; TCD-DI-HEA = 2-propenoicacid; (octahydro-4,7-methano-1H-indene-5 - diyl) bis (methyleneiminocarbonyloxy-2,1-ethanediyl) ester; TiO2 = Titanium dioxide, YbF3 = Ytterbium trifluoride; B2O3-F-Al2O3-SiO2 = Boro-fluoro-aluminosilicate. * The data were provided by the manufacturers.

In the experimental group, a total of 160 samples were prepared, including four mouthwashes in which we would keep the samples colored with coffee, a group in which these mouthwashes would be applied with an oral irrigator; Oral-B Oxyjet (Procter& Gamble, USA), and a control group consisting of 40 samples in which distilled water (DW) would be applied directly and with an oral irrigator, and a total of 200 samples were prepared (n=10). Mouthwashes used in the experiment: Sensodyne Promine (SP), Colgate Plax activated charcoal and whiteness (CP), Crest 3D White (CW), Listerine Fresh Burst (LF) and their brand names, manufacturers and ingredients are presented in Table 2.

Table 2. The brand names, manufacturers, ingredients of mouthwashes used in this study.

Mouthwash	Manufacturer	Ingredients
Listerine Fresh Burst (LF)	Johnson & Johnson, UK	Alcohol, menthol, eucalyptol, thymol, methyl salicylate, benzoic acid, poloxamer 407, sodium benzoate, sorbitol solution, water, flavor
Colgate Plax Whitening + Charcoal (CP)	Colgate-Palmolive, USA	Water, sorbitol, propylene glycol, PEG-40 hydrogenated castor oil, flavor, sodium saccharin, menthol, eugenol, sodium fluoride, charcoal powder
Crest 3D White (CW)	Procter & Gamble, USA	Water, glycerin, hydrogen peroxide, propylene glycol, sodium hexametaphosphate, poloxamer 407, sodium citrate, flavor, sodium saccharin, citric acid
Sensodyne Pronamel (SP)	GSK, UK	Water, sorbitol, propylene glycol, potassium nitrate, PEG-60 hydrogenated castor oil, poloxamer 407, flavor, sodium fluoride, citric acid, sodium saccharin

Specimen Preparation

Composite disc-shaped specimens were prepared using 2 mm thick, 8 mm diameter silicon mold. The material placed in the molds was covered with transparent strip (Universal strips, Extra Dental, Istanbul, Turkey) and finger pressure was applied with a glass slide. After ensuring that there were no air bubbles on the surface, polymerization was performed using a VALO Cordless LED curing light (Ultradent, USA) at 1000 mW/cm^2 following the manufacturer's instructions, and light exposure was provided on both the upper and lower surfaces. After polymerization, each specimen was polished with discs (SofLexTM XT, 3M ESPE, USA) in order from coarse to fine grain. Then, they were polished with the Diamond Polish system kit (SofLex, 3M ESPE, USA).

Staining Procedure

All prepared specimens were stored in distilled water for 24 hours. Samples were kept in coffee solution (Nescafe Classic, Nestle, Switzerland) prepared by dissolving 3 grams of coffee in 50 mL of boiling water for 12 days, equivalent to one year's use. The solution was renewed daily (Korkut et al., 2020).

Surface Roughness Measurement (Ra)

Before and after the discoloration procedure, roughness measurements of samples were made. Measurements were made from 3 different areas using a contact profilometer (Mitutoyo, Japan) roughness measuring device and Ra values were recorded. Calibration of the device was performed after each new group according to the manufacturer's instructions and using the calibration plate, which is a part of the device. After calibration, each sample was placed on the standard measurement table of the device in order so that the contact angle between the profilometer's reader tip and the sample disk was 90°. Measurements were made by taking care to ensure that the samples were in the center. Three measurements were taken from each sample and the average of the values was taken.

After the experiment was completed, the surface roughness of the samples was measured

again under the same conditions and the values were recorded.

Mouthwashes Application

The samples in the group where mouthwashes would be applied directly were placed in the solutions and kept for 12 hours. It was reported that this period was equal to using mouthwash twice a day for one minute (Haghi et al., 2023), and corresponds to approximately one year of clinical use. In the other group, each solution was placed separately in the mouthwash device and applied once a week for 4 weeks for 10 minutes each use in order to extend the process and better simulate the clinical situation. It was reported that this period was equivalent to using the device twice a day for 3 seconds on each surface (Alavi et al., 2022), and corresponds to approximately one year of clinical use. The tip of the device was fixed vertically to the surface of the samples at a distance of 2 mm in accordance with the manufacturer's instructions. The samples were fixed to the inner surface of a plastic container from their backs with double-sided tape, and the device was placed at a distance of 2 mm so that it would remain stable on its stand. The device was adjusted to a medium level to apply a constant pressure again in accordance with the manufacturer's instructions. The liquid chamber of the device was continuously filled with the relevant solution and applied so that it could be used continuously until the end of the experiment. Each sample was then rinsed with water spray for 10 seconds and stored in distilled water at room temperature until the next stage of the treatment.

Statistical Analysis

The Ra data were analyzed using R software with a robust two-way repeated measures ANOVA approach to accommodate any non-normal distributions and outliers in roughness data (5% trimmed means were used for robustness). The factors in the ANOVA were: Composite type (DO vs VU, between-subjects), Application method/

solution (5×2 combinations, treated as a single between-subjects factor with 10 levels, since each specimen was in one combination of method and solution), and Time (after staining vs after treatment, within-subjects). The three-way interaction (Composite × Group-Solution × Time) was tested. Post hoc comparisons were performed with Bonferroni adjustment for multiple comparisons. In addition, paired t-tests (with Bonferroni correction) were used to compare roughness before and after treatment within each subgroup. Significance was set at $p<0.05$. Statistical results are presented as mean ± standard deviation (SD) unless otherwise noted.

RESULTS

Comparison of surface roughness values according to composite type, group and solution, and time is presented in Table 3. Regardless of solution and time, the main effect of composite type was found to be statistically significant on surface roughness values ($p<0.001$).

Table 3. Comparison of surface roughness values according to composite type, group and solution, and time.

Source of Variation	Q	p-value
Composite	15.170	<0.001
Group and Solution	21.900	0.016
Time	366.700	0.001
Composite × Group and Solution	30.120	0.002
Composite × Time	3.280	0.197
Group and Solution × Time	13.320	0.814
Composite × Group and Solution × Time	9.200	0.965

*Q: Robust regression-based ANOVA test statistic.

According to the multiple comparison results of surface roughness values, the mean surface roughness value of the DO composite was higher (0.198) compared to the VU composite (0.186) (Table 4).

Table 4. Multiple comparison results of surface roughness (Ra, µm) based on composite type, group, mouthwash solution, and time intervals.

Group and Solution	Time	Composite		Total
		DO	VU	
CP’	T_0	0.175 ± 0.016	0.144 ± 0.014	0.158 ± 0.008
	T_1	0.268 ± 0.027	0.195 ± 0.01	0.227 ± 0.015
	T_2	0.201 ± 0.017	0.158 ± 0.017	0.177 ± 0.01
	Total	0.211 ± 0.013	0.167 ± 0.009	0.186 ± 0.007
CW’	T_0	0.171 ± 0.012	0.168 ± 0.014	0.17 ± 0.008
	T_1	0.239 ± 0.018	0.227 ± 0.017	0.232 ± 0.012
	T_2	0.192 ± 0.012	0.186 ± 0.015	0.19 ± 0.009
	Total	0.199 ± 0.01	0.193 ± 0.009	0.195 ± 0.006
SP’	T_0	0.168 ± 0.009	0.142 ± 0.015	0.157 ± 0.008
	T_1	0.239 ± 0.016	0.212 ± 0.015	0.224 ± 0.01
	T_2	0.2 ± 0.014	0.171 ± 0.017	0.186 ± 0.011
	Total	0.2 ± 0.009	0.175 ± 0.01	0.188 ± 0.007
LF’	T_0	0.159 ± 0.01	0.172 ± 0.009	0.166 ± 0.006
	T_1	0.249 ± 0.017	0.262 ± 0.021	0.257 ± 0.013
	T_2	0.205 ± 0.013	0.208 ± 0.013	0.208 ± 0.008
	Total	0.203 ± 0.01	0.214 ± 0.011	0.208 ± 0.008
DW’	T_0	0.173 ± 0.01	0.148 ± 0.011	0.163 ± 0.007
	T_1	0.255 ± 0.02	0.232 ± 0.018	0.246 ± 0.012
	T_2	0.212 ± 0.017	0.181 ± 0.012	0.195 ± 0.01
	Total	0.213 ± 0.011	0.187 ± 0.01	0.199 ± 0.007
CP	T_0	0.162 ± 0.008	0.151 ± 0.007	0.156 ± 0.005
	T_1	0.257 ± 0.02	0.215 ± 0.01	0.233 ± 0.011
	T_2	0.199 ± 0.016	0.162 ± 0.013	0.176 ± 0.009
	Total	0.204 ± 0.011	0.175 ± 0.008	0.187 ± 0.007
CW	T_0	0.147 ± 0.007	0.163 ± 0.011	0.155 ± 0.006
	T_1	0.205 ± 0.009	0.245 ± 0.02	0.223 ± 0.011
	T_2	0.192 ± 0.011	0.188 ± 0.015	0.191 ± 0.008
	Total	0.181 ± 0.007	0.198 ± 0.011	0.188 ± 0.006
SP	T_0	0.145 ± 0.009	0.143 ± 0.009	0.144 ± 0.006
	T_1	0.21 ± 0.009	0.212 ± 0.009	0.21 ± 0.006
	T_2	0.204 ± 0.016	0.175 ± 0.018	0.189 ± 0.012
	Total	0.186 ± 0.008	0.176 ± 0.009	0.181 ± 0.006
LF	T_0	0.158 ± 0.012	0.152 ± 0.009	0.157 ± 0.007
	T_1	0.239 ± 0.016	0.238 ± 0.018	0.237 ± 0.011
	T_2	0.207 ± 0.015	0.21 ± 0.014	0.209 ± 0.01
	Total	0.202 ± 0.01	0.199 ± 0.011	0.2 ± 0.007
DW	T_0	0.146 ± 0.011	0.151 ± 0.01	0.149 ± 0.007
	T_1	0.221 ± 0.014	0.229 ± 0.016	0.223 ± 0.01
	T_2	0.214 ± 0.017	0.182 ± 0.011	0.196 ± 0.01
	Total	0.193 ± 0.01	0.186 ± 0.009	0.189 ± 0.007
Toplam	T_0	0.16 ± 0.003	0.154 ± 0.003	0.157 ± 0.002[c]
	T_1	0.235 ± 0.005	0.226 ± 0.005	0.231 ± 0.004[b]
	T_2	0.201 ± 0.004	0.183 ± 0.005	0.192 ± 0.003[a]
	Total	0.198 ± 0.003	0.186 ± 0.003	0.192 ± 0.002

*Trimmed Mean ± Standard Error; a-c: No significant difference among main effects sharing the same lowercase letter; A-J: No significant difference among interaction groups sharing the same uppercase letter; Trimmed mean method was used as the analysis approach with a trimming proportion of 5%.

Abbreviations: **CP:** Colgate Plax Whitening + Charcoal (direct application); **SP:** Sensodyne Pronamel (direct application); **CW:** Crest 3D White (direct application); **DW:** Distilled Water (direct application); **LF:** Listerine Fresh Burst (direct application); **CP’:** Colgate Plax Whitening + Charcoal (applied with oral irrigator); **SP’:** Sensodyne Pronamel (applied with oral irrigator); **CW’:** Crest 3D White (applied with oral irrigator); DW’: Distilled Water (applied with oral irrigator); **LF’:** Listerine Fresh Burst (applied with oral irrigator); VU: Vittra APS Unique composite resin; **DO:** Charisma Diamond One composite resin; T_0: Initial; T_1: After coffee immersion; T_2: After mouthwashes application.

The main effect of solution type was also statistically significant ($p = 0.016$) (Table 3), although pairwise comparisons did not reveal a significant difference between specific solution groups. Among all solutions, the highest surface roughness value was observed in the LF’ group (0.208), while the lowest was found in the SP group (0.181) (Table 4 and Figure 1). The main effect of time was significant ($p = 0.001$); mean roughness values increased from baseline (t0; 0.157) to post-coffee exposure (t1; 0.231), then slightly decreased after mouthwash application (t2; 0.192).

The main effect of the interaction between composite type and solution was found to be statistically significant ($p = 0.002$). Among the composite-solution combinations, the VU composite exhibited the highest surface roughness value when exposed to Listerine Fresh Burst (mean = 0.214), while the lowest roughness value was recorded in the same composite with CP solution (mean = 0.167). In contrast, the interactions between composite and time, solution and time, as well as the three-way interaction among composite, solution, and time were not statistically significant (p>0.05), indicating that these factors did not result in meaningful differences in surface roughness values.

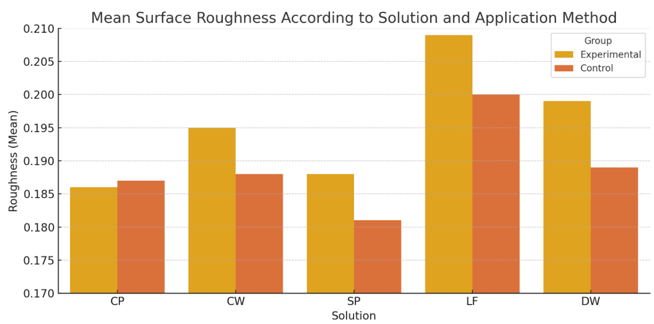

Figure 1. Mean Surface Roughness According to Solution and Application Method

These results indicate that both the type of composite and the type of solution significantly influenced the surface roughness, while the effect of time and specific composite-solution combinations also contributed to the variation in surface texture. However, no consistent pattern of surface roughness reduction or increase was observed between the experimental (mouthwash applied via irrigator) and control (direct immersion) groups across all solutions.

DISCUSSION

In this study, the surface roughness of two single-shade nanohybrid resin composites; Charisma Diamond One and Vittra APS Unique was evaluated after exposure to coffee staining and different mouthwashes, applied either directly or via an oral irrigator. Both composites exhibited similar surface behavior overall, aligning with recent studies reporting comparable roughness outcomes in universal shade nanohybrid materials (Lucena et al., 2021). Slight differences observed between the two may be attributed to compositional factors: Charisma Diamond One contains larger filler clusters, which may become more easily dislodged or exposed under mechanical or chemical stress, while Vittra APS Unique incorporates finer zirconia-silica fillers, potentially enhancing polishability and surface resistance (Yilmaz Atalı et al., 2022; Duratbegović et al., 2024).

Coffee exposure has been shown to increase surface roughness in single-shade resin composites, aligning with studies indicating that acidic and chromogenic beverages can degrade the resin matrix, leading to erosion and pigment retention (Rohym et al., 2023).

The findings of this study regarding the application of mouthwash with an oral irrigator align with several previous reports. Alharbi and Farah (2020) demonstrated that oral irrigator had no significant effect on the surface roughness or color stability of resin-based composites, emphasizing the safety of such devices when used within clinical pressure limits. Naser-Alavi et al. (2022) investigated the effect of oral irrigation using water and chlorhexidine at different pressures on bulk-fill composites and found the oral irragator using increased the surface roughness values. In a more recent study, Alavi et al. (2023) evaluated the impact of varying pressures and irrigating solutions on Giomer, another resin-based material, and reported that oral irrigator use at high pressure, increased the surface roughness values of the material. In the present study, surface roughness values increased after coffee immersion, and while oral irrigator application slightly reduced this roughness, the values did not fully return to baseline. However, the final roughness remained within clinically acceptable limits (≤0.2 µm). These findings may support that oral irrigator use at clinically appropriate pressure levels may lead to minimal surface alterations in composite resins, remaining within acceptable roughness thresholds. However, considering the variability in device settings, application techniques, and material compositions, further studies are needed to better define the optimal parameters for safe and effective clinical use.

In this study, the activated charcoal-based mouthwash (Colgate Plax Whitening + Charcoal) demonstrated a greater reduction in surface roughness of nanohybrid composites after coffee-induced staining compared to the hydrogen peroxide-based mouthwash (Crest 3D White). This finding aligns with previous research indicating that hydrogen peroxide-containing whitening agents can increase surface roughness due to their oxidative effects on the resin matrix (Hamdy et al., 2022). Conversely, while activated charcoal has been associated with abrasive properties, its impact on surface roughness appears to be less pronounced. For instance, Sarıalioğlu Güngör et al. (2023) reported that an activated charcoal-containing toothpaste (Colgate Optic White Charcoal) resulted in a lower percentage change in enamel surface roughness (ΔRa =-39.73±8.84) compared to a hydrogen peroxide-containing toothpaste (Colgate Optic White Expert) (ΔRa = - 55.16±3.77). These findings suggest that activated charcoal-based whitening agents may be less detrimental to the surface integrity of dental tissues and restorations than their hydrogen peroxide counterparts.

Among all the mouthwashes tested, only Listerine Fresh Burst contained alcohol, and it led to slightly higher surface roughness values compared to the alcohol-free alternatives. This observation is consistent with prior findings that ethanol-based formulations can soften the resin matrix by partially dissolving the polymer network, contributing to microstructural alterations and surface degradation (Yilmaz & Mujdeci, 2021). However, the observed roughness increase was modest, likely due to the short duration of exposure and the high resistance of nanohybrid composites to chemical challenges.

The findings of this study provide partial support for the null hypotheses. No statistically significant difference was found between the two nanohybrid composites tested (Charisma Diamond One and Vittra APS Unique) indicating that composite type did not significantly influence surface roughness. Similarly, the method of application (direct immersion vs. oral irrigator) showed no significant effect, supporting the third null hypothesis. However, the main effect of mouthwash type on surface roughness was statistically significant ($p=0.016$), suggesting that certain formulations may alter surface texture more than others. Although pairwise comparisons between specific rinses were not provided, trends observed in the data (e.g., higher roughness with peroxide - and alcohol-containing rinses) support rejecting the second null hypothesis. These results highlight that while composite formulation and application method may be less critical under short-term conditions, the chemical composition of oral hygiene products can play a significant role in surface degradation.

In this study, surface roughness was assessed using a contact profilometer, which is widely accepted as a gold standard for quantitative surface analysis in dental material research. Stylus-based profilometry provides high-resolution and reproducible measurements of Ra values, making it particularly suitable for detecting fine surface irregularities on resin-based composites following chemical or mechanical exposure. Compared to non-contact optical techniques, contact profilometers offer enhanced sensitivity in tracing topographical changes. The use of a calibrated, standardized device in this study ensured precise evaluation of surface alterations, thereby supporting the validity and reliability of the reported data (Yılmaz Atalı et al., 2022).

In this study, the use of the VALO Cordless LED curing light ensured optimal polymerization of the composite specimens. High-intensity LED units like VALO Cordless provide effective light penetration and uniform polymerization, which contribute to enhanced surface hardness and resistance to degradation (Duratbegović et al., 2024). In addition, the application of the multi-step 3M Sof-Lex polishing system helped achieve smoother composite surfaces. Previous studies have demonstrated that multi-step polishing protocols produce significantly lower surface roughness compared to simplified one-step systems, supporting improved aesthetics and long-term clinical success (Chowdhury et al., 2023). These standardized procedures likely contributed to maintaining surface roughness within clinically acceptable limits throughout the experimental phases.

Despite observable trends in surface roughness changes, not all intergroup differences reached statistical significance. This may be attributed to the short duration of exposure or the inherent chemical and mechanical stability of nanohybrid composites. These materials typically exhibit high filler loading, advanced silane coupling, and optimized resin matrices that improve resistance to softening, hydrolytic degradation, and wear (Duratbegović et al., 2024; Yılmaz Atalı et al., 2022). Overall, the findings suggest that while coffee immersion can increase surface roughness, commonly used mouthrinses—particularly alcohol-free or milder formulations—are unlikely to cause significant surface degradation in the short term.

CONCLUSION

Within the limitations of this in vitro study, it can be concluded that surface roughness of single-shade nanohybrid resin composites is influenced by chemical exposure, particularly the type of mouthwash and prior staining. Key findings are summarized as follows:

1. Coffee immersion significantly increased surface roughness, confirming its potential to chemically degrade composite surfaces under prolonged exposure.
2. Hydrogen peroxide-containing whitening mouthwash caused greater surface roughness compared to the charcoal-based rinse, likely due to its oxidative mechanism.
3. The alcohol-containing rinse (Listerine Fresh Burst) produced slightly higher roughness values than alcohol-free alternatives, although differences remained within clinically acceptable limits.
4. No statistically significant difference was observed between the two composite types or between the application methods (direct vs. oral irrigator), indicating the materials' high resistance to surface degradation.
5. All tested resin composites maintained surface roughness values below critical thresholds for biofilm accumulation, supporting their clinical suitability in restorative dentistry.

These results indicate that while nanohybrid composites demonstrate excellent surface resilience, the chemical composition of mouthwashes plays a key role in surface integrity. Clinicians should consider the impact of peroxide and alcohol-containing oral care products on composite restorations. Future research should include long-term aging, mechanical fatigue, and combined chemical-mechanical cycling to better simulate intraoral conditions.

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Conflicts of Interest:

The authors have no financial interest in any companies or products mentioned in this article.

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