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Effect of Different Bleaching Systems on Surface Roughness of Two Nano-hybrid Composite Resins

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Abstract

Objective: This research aimed to assess the impact of 40% hydrogen peroxide bleaching in the workplace and 16% carbamide peroxide bleaching at home on the composite's surface roughness based on Omnichroma and Evetric resin. Materials and Methods: 24-disc composite samples, each measuring 5 mm in diameter and 2 mm in height, were created for this in vitro experimental investigation using every kind of nano-hybrid resin composite material. All composite group's samples were randomly split into 3 subgroups (n=8). Samples in the control subgroup were kept for a week at 37°C in artificial saliva. 40% hydrogen peroxide was used to bleach in-office bleaching samples. Samples of home bleaching were be bleached by 16% carbamide peroxide. Measurements of surface roughness were made for every sample in every subgroup. Samples of control sub-group were be considered as base line data. Both parametric and non-parametric statistical analyses were performed at $P \leq 0.05$ using the SPSS software (version 25 for Windows). Results: For both studied materials, all subgroups' surface roughness levels dropped below the threshold point (Ra<0.2 µm). The Kruskal–Wallis test revealed a significant difference among the Omnichroma subgroups ($p = 0.002$). Additionally, the one-way ANOVA confirmed a significant difference among the Evetric subgroups ($p=0.035$). Conclusions: All tested subgroups of both Omnichroma and Evetric composites showed surface roughness degree below the clinically acceptable threshold (Ra < 0.2 µm). Bleaching with 40% H_2O_2 and 16% carbamide peroxide gels did not produce a clinically significant increase in surface roughness for either material.

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Introduction

Resin composites are widely employed in dentistry as aesthetic restorative materials because of their superior visual appearance, sufficient strength, and capacity to adhere to tooth structure [1]. Obtaining a restoration with smooth surfaces and no porosities is one of the main goals when applying a composite restoration; Because rough-surfaced restorations encourage plaque buildup, discoloration, gingival irritation, and secondary caries, surface roughness is a critical element influencing the clinical performance of composite restorative materials. [2].

Regular eating patterns and the oral environment can alter the surface characteristics of resin composites, which in turn can impact the long-term stability of composite restorations. Furthermore, resin composite restorations may be negatively impacted by some dental procedures, including as bleaching, a simple and non-invasive technique for teeth whitening that principally relies on when hydrogen peroxide or one of its precursors oxidizes [3]. In contrast to alternative tooth-colored restorative materials, because resin composites have an organic matrix, they are more prone to negative consequences after teeth whitening. The degradation of resin composites' polymer network due to peroxides in

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bleaching chemicals may result in an elevated level of surface roughness [4].
The kind and proportion of the resin composites' organic matrix and fillers, as well as the bleaching agent's concentration and application duration, all affect how resin composite restorations react to whitening agents [3]. This study aimed to assess the impact of 40% hydrogen peroxide in-office bleaching gel and in-home bleaching gel containing 16% carbamide peroxide on the surface roughness of two different nano-hybrid resin composite materials. The impact of bleaching chemicals on the surface roughness of different resin composite materials has been independently evaluated in numerous research. The hypothesis being tested was that the nano-hybrid resin composite's surface roughness was unaffected by bleaching with 16% carbamide peroxide bleaching gel at home and 40% hydrogen peroxide bleaching gel in the workplace.

Material and Methods

Preparing and classifying samples

48 samples (24 samples from each nano type) were created using two distinct nano-hybrid composite resin materials: Omnichroma resin-based composite from Tokuyama Dental, Japan, and Evetric nano-hybrid composite from Ivoclar Vivadent, Schaan, Liechtenstein. Since Omnichroma composite has the special quality of having a universal shade, Shade A2 was used for Evetric, and universal shade was used for Omnichroma.
The samples were made using a polyurethane mold. The disk-shaped samples had dimensions of 2 mm for height and 5 mm for diameter [5]. After filling the polyurethane mold with the tested composite material, it was placed on a mylar strip over a glass slab and topped with a glass slab and another mylar strip [6]. By reducing the oxygen-inhibiting layer, the mylar strip will enhance the surface quality [7]. The material was then compacted by crushing the mold with a 500g weight for 30 seconds, allow surplus material to flow out, avoid the creation of voids and bubbles, and create parallel surfaces [6]. After stopping the load, the samples were exposed to light for 20 seconds from top to bottom through the glass slab (40 seconds total) employing an LED light-curing equipment with a 1000 mW/cm2 light intensity (Blue phase, Woodpecker, China). The specimen and light source distance was standardized by placing the light-curing unit's tip directly against the 1 cm thick glass slab [8]. After polymerization, the lateral sides of each sample were polished using polishing discs covered in aluminum oxide, then the samples were cleaned and engrossed in synthetic saliva for a whole day at 37°C [9].
24 samples were created using each nano resin composite material, and the samples of the two nano types were split into two main groups at random:
Group 1. Evetric nano-hybrid composite (24 samples).
Group 2: Composite made of Omnichroma resin (24 samples).
Three subgroups were randomly selected from the two main sets of composite samples, and each subgroup contained eight samples of every kind of composite resin substance:
Control subgroup: Following a week of storage at 37°C in artificial saliva, measurements of surface roughness served as the baseline.
Subgroup for in-office bleaching: After the samples were chemically bleached using 40% H_2P_2 gel, assessments of surface roughness were made.
Subgroup for home bleaching: After the samples were chemically bleached using 16% CP gel, assessments of surface roughness were made.
Table 1 lists the primary components of the items used in this investigation.

Bleaching procedure

Utilizing the chemical bleaching system (Opalescence boost, Ultradent, USA) designed exclusively for use in dental offices, specimens of in-office bleaching sub-groups were treated with a bleaching product comprising 40% hydrogen peroxide gel. Using a cotton applicator, the bleaching chemical was evenly distributed on one surface of each specimen using a syringe in an equal quantity. The gel remained on sample surface for 20 minutes, then the gel was suctioned with a suction tip, this procedure was repeated for three times in line with the manufacturer's guidelines. In the home bleaching sub-group, samples were exposed to 16% carbamide peroxide bleaching gel (Cavex Bite and White ABC Master kit, Netherlands) for 60 minutes every day for 14 days. After that, samples were rinsed under flowing water for a minute to get rid of any last traces of bleaching agent and dried with a triple syringe for ten seconds before surface roughness measurements were taken. Every day and after bleaching procedure, after giving the samples a thorough rinse under flowing water, they were incubated at 37°C in artificial saliva. Following the bleaching process, samples were rinsed under flowing water for one minute to remove any remaining bleaching agent from their surfaces. They were then dried for ten seconds with a triple syringe before measures of surface roughness were made.

Surface roughness measurement procedure

A standard profilometer can measure small vertical features with heights between 10 and 1 millimeters. The diamond stylus's height position creates an analog signal. It is subsequently converted into a digital signal for recording, analysis, and display on a screen. Surface roughness (Ra) was measured using the contact profilometer method. Using this technique, a measurement stylus—mostly a diamond, which has a diameter of 20 to 25 nanometers—is pulled laterally across a sample after coming into vertical contact with it, for a preset contact force that may range from less than 1 to 50 milligrams [5]. The surface texture alterations of Omnichroma and Evetric resin-based composite samples after both bleaching processes were assessed using a Taylor-Hobson stylus profilometer. First, the control subgroups' Ra values were obtained and used as baseline information. Each sample was measured three times in different locations, while the profilometer's end is in touch with the center of the sample. For standardization purposes, the measurement was then repeated from a distance of 1 mm from the sample's center on the left and right. The sample's surface roughness value was then determined by averaging the three readings [4]. All subgroups' variations in the average (Ra) values in micrometers (µm) were noted and examined.

Statistical analysis

Software called SPSS (version 25 for Windows) was used to do statistical analysis. Non-parametric tests were selected because the Omnichroma group's normality test demonstrated that the data did not follow a normal distribution, however parametric tests were chosen because the data did follow a normal distribution according to the Evetric group's normality test.

Results

The average surface roughness (Ra) values in µm and the standard deviation of the two nano-hybrid resin composite materials' three subgroups are showed in Table 2. All subgroups of the two tested materials had mean roughness values (Ra) that were below the critical limitations ($Ra < 0.2$ µm). A Kruskal–Wallis non-parametric test was performed to compare the three subgroups of the Omnichroma group (Table 3). The Kruskal–Wallis test revealed a statistically significant difference between the groups ($H=12.121$, $df=2$, $p=0.002$). This indicates that there is a significant difference among the studied subgroups,

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with the 40% bleaching subgroup showing higher mean ranks compared to the others. A one-way ANOVA was conducted to compare the means of the three subgroups of Evetric group (Table 4). Since p = 0.035 < 0.05, This means that there is a significant difference among the studied subgroups of Evetric tested material. Comparison between OMNI 16% and Evetric 16% subgroups using Mann–Whitney test, as shown in Table 5. There was a significant difference between Omnichroma 16% and Evetric 16% (p=0.001). Omnichroma group exhibited lower surface roughness compared to Evetric, indicating a smoother surface after bleaching with 16% gel.

Comparison between OMNI 40% and EVETRIC 40% subgroups using independent t-test, as shown in Table 6. There was no significant difference between Omnichroma 40% and Evetric 40% (p=0.266). Although Evetric showed slightly higher mean roughness values, the difference was not statistically significant.

Discussion

This study looked at how the surface roughness of two distinct types of resin composites was affected by in-office bleaching using 40% H_2O_2 and 16% carbamide peroxide. Since whitening teeth has become a standard dental procedure, it is important to consider how bleaching agents affect the appearance and surface texture of composite restorative materials [10]. Researchers and clinicians have been particularly concerned with the surface roughness of restorative materials because it is a significant clinical characteristic that has been shown to have an impact on oral health and dental aesthetics. Because it increases the likelihood of external staining, plaque formation, gingival irritation, and periodontal disease, increasing the superficial roughness of restorative materials above the threshold value (0.2 µm) is considered clinically important [6]. Resin composites are biphasic, made up of filler particles and a resin matrix. By plasticizing and expanding the resin component, hydrolyzing the silane, and forming microcracks at the interface between the fillers and the matrix—which could lead to an increase in surface roughness—an elevated in water sorption can reduce the lifespan of the composite [11]. The addition of hydrophilic monomers to the resin matrix was thought to be the cause of the rise in fluid uptake, or water sorption. Because of the hydroxyl group in their chemical structure, Bis-GMA and TEGDMA are hydrophilic monomers; in contrast, UDMA has a lower water sorption and is less hydrophilic than TEGDMA and Bis-GMA, making it more withstands to surface texture changes and solubility [1].

It is expected that composites made of resin with a tiny filler size and a high filler loading will have advantageous qualities, be less susceptible to bleaching agents, and be more resilient to surface topography changes and degradation [12]. On the surface of composite restorative materials, hydrogen peroxide generates free radicals with a broad spectrum of diffusion and penetration capabilities, which causes the polymer network to degrade. Consequently, it is anticipated that a resin composite with a larger amount of resin will be more vulnerable to bleaching material deterioration [10]. Additionally, the high-energy free radicals generated at the resin-filler contact by peroxides may cause water uptake and whole or partial filler-matrix detachment. This speeds up resin composites' hydrolytic breakdown, increasing filler particle dispersion and debonding and, eventually, the restorative material's surface roughness [13]. This explained why 40% H_2O_2 significantly impact the two nanohybrid composite materials' surface roughness.

According to Gül et al. [10], bleaching techniques significantly increased the surface roughness of the studied samples, which they attributed to the composite resin matrix degrading. Bahari et al., Varanda et al., and Yikilgan et al. on the other hand, conducted research [4,6,14]. concluded that the surface roughness of resin composite materials is not significantly impacted by bleaching chemicals. These findings supported the current study's findings that hydrogen peroxide bleaching caused a minor elevate in surface roughness, but that this elevate was not statistically or clinically significant since (Ra <0.2 µm) and (P>0.05). Because the resin matrix degraded less in nano-hybrid resin composites, these findings explained that hydrogen peroxide had no impact on changes in surface characteristics.

Omnichroma nano-hybrid composite materials exhibited lower surface roughness compared to Evetric after bleaching with 16% gel, this may be due to the silica of Omnichroma can help resin composites resist surface roughness following bleaching; this was in line with Dogan et al.'s [15]. Consequently, barium containing glass fragments are more vulnerable to hydrolytic attack than quartz or silica. The notion that bleaching had no effect on the nano-hybrid resin composite's surface roughness was accepted. Both materials are suitable options for patients who will eventually receive bleaching treatments because a comparison of the roughness levels of the two materials under test was inconclusive (P>0.05). The fact that this study was carried out in vitro and that it was not feasible to replicate oral conditions directly are some of its limitations. Because of this, bleaching agents may have different effects in vitro and in vivo on the surface roughness of restorative materials.

Conclusions

Within limitation of this study, all tested subgroups of both Omnichroma and Evetric composites showed surface roughness values below the clinically acceptable threshold (Ra <0.2 µm). bleaching with 16% and 40% carbamide peroxide gels did not produce a clinically significant increase in surface roughness for either material. However, Omnichroma composite exhibited slightly lower mean surface roughness values compared to Evetric under both bleaching concentrations, indicating better surface smoothness and higher resistance to surface alteration following bleaching procedures.

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Table 1. Lists the primary components of the goods used in this investigation.

Product	**Type**	**Construction**
Evetric	Nano-hybrid composite	**Matrix**: 19–2 weight percent dimethacrylates. **Filler**: copolymers (80–81 weight percent), mixed oxide, barium glass, and ytterbium trifluoride. Additional contents (less than 1 weight percent) include colors, stabilizers, initiators, and additives. Inorganic fillers make about 55–57 vol.% of the total. Inorganic fillers range in particle size from 40 nm to 3000 nm.
Omnichroma	Nano-hybrid composite (Universal shade)	**Matrix:** UDMA, TEGDMA, 1,6 (methacryl ethyloxycarbonylamino). **Filler**: Zirconium-silica sphere filler. between 0.2 and 0.6 µm. 0.3µm is the average particle size (79%w, 68% v).
Opalescence boost	In-office Chemical Bleaching	40% Hydrogen Peroxide.
Cavex Bite and White ABC Master kit	Home bleaching	16% Carbamide peroxide, 6% waterstofperoxide, 0.2% kaliumnitraat-desensitizer, 0.1% Natriumfluoride-desensitizer
Artificial saliva	Ready-made	Glycerol, methylparaben, propylparaben, Mint taste with calcium chloride, magnesium chloride, sodium chloride, potassium chloride, dibasic sodium phosphate, carboxymethylcellulose, and sorbitol (30 mg/ml), pH (7).

Table 2. Surface roughness (Ra) descriptive statistics (mean and standard deviation) for each of the two tested materials' subgroups.

	Omnichroma Composite Surface Roughness (Ra)		Evetric Composite Surface Roughness (Ra)	
	Mean (µm)	Std. Deviation	Mean (µm)	Std. Deviation
Control gp	0.0868	0.11887	0.0709	0.01733
16% gp	0.0580	0.00926	0.0836	0.00862
40% gp	0.0834	0.00998	0.0913	0.01642

Table 3. A Kruskal–Wallis test for all sub-groups of Omnichroma tested material.

Group	N	Mean Rank
1 (Control)	8	7.63
2 (16%)	8	10.50
3 (40%)	8	19.38

Table 4. A one-way ANOVA test for all sub-groups of Evetric tested material.

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.002	2	0.001	3.947	0.035
Within Groups	0.005	21	0.000		
Total	0.006	23			

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Table 5. Mann–Whitney test for comparison between OMNI 16% and Evetric 16% subgroups.

subgroups	Mean Rank	Sum of Ranks	p-value
OMNI 16%	4.56	36.50	0.001
EVETRIC 16%	12.44	99.50	0.001

Table 6. Independent t-test for comparison between Omnichroma 40% and Evetric 40% subgroups.

Subgroups	N	Mean	Std. Deviation	p-value
OMNI 40%	8	0.0834	0.00998	0.266
EVETRIC 40%	8	0.0912	0.01642	0.266