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Effect of an alcohol containing-mouthwash on the surface roughness of a nanohybrid composite resin

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Abstract

Objective: This study aimed to compare the surface roughness of a nanohybrid composite resin after immersion in an alcohol-containing mouthwash and a non-alcoholic mouthwash.

Methods: Twenty-seven cylindrical nanohybrid composite resin samples were prepared and immersed in distilled water in an incubator for 24 hours, then divided into three groups. The samples in Group 1 were immersed in an alcohol-containing mouthwash (Listerine® Zero with 21.6% alcohol), while those in Group 2 were immersed in a non-alcoholic mouthwash (Listerine® Zero). Group 3 samples were immersed in a saline solution as the control. The samples were subjected to 12 cycles of 1-minute immersion in the respective solution per day. Between the cycles, samples were kept in distilled water at 37°C. The procedure was repeated for 30 days, totalling 360 cycles. The average surface roughness (Ra) of the composite samples was measured using a stylus-based surface roughness tester after the immersion cycles.

Results: ANOVA revealed a significant difference in surface roughness among the study groups (P = 0.011). Tukey test showed that the alcohol-containing mouthwash caused significantly greater roughness in the nanohybrid composite resin compared to the non-alcoholic mouthwash and saline solution (P<0.05).

Conclusions: The surface roughness of nanohybrid composite resin was significantly increased after exposure to the alcohol-containing mouthwash compared to the non-alcoholic mouthwash and saline. This increased roughness can potentially compromise the clinical performance of esthetic restorative materials by promoting surface degradation and reducing wear resistance, and should be considered in clinical practice.

Keywords: Alcohol, Composite resin; Degradation, Immersion, Mouthwash, Roughness

Introduction

Caries, a common dental problem, affects about 98% of the global population. According to the World Health Organization (WHO) in 2023, 60-90% of school-aged children and nearly all adults experience dental caries at some point, which significantly impacts their quality of life. In Indonesia, Basic Health Research in 2013 showed an increase in the prevalence of active caries from 43.4% in 2007 to 53.2% in 2013, implying that approximately 93,998,000 people are affected by this condition (1).

Mechanical removal of dental plaque with toothbrushes and dental floss remains the most effective and primary means of plaque control, as it physically disrupts and removes the bacterial biofilm. However, even with meticulous brushing and flossing, only about 25% of oral surfaces are cleaned, leaving a significant proportion of the mouth, such as the tongue, cheeks, and interproximal areas, less accessible to mechanical methods. Chemical plaque control with antimicrobial mouthrinses offers substantial adjunctive benefits, reaching areas inaccessible to brushing and flossing and resulting in further reductions in oral bacterial counts and plaque accumulation (2).

Many over-the-counter mouthwashes contain alcohol as a key ingredient. Alcohol functions as a solvent, stabilizer, and preservative in these formulations (3-5). Furthermore, the combination of active ingredients, such as essential oils, with alcohol may enhance the inhibition of bacterial growth more effectively than essential oils alone. (2). This synergy highlights alcohol's role in improving the antimicrobial effects of mouthwashes

Despite its benefits, the presence of alcohol in beverages can have adverse effects on the appearance and integrity of composite resin materials (6). Miranda et al. (7) reported that beverages containing 9% or more alcohol can weaken the resin matrix, resulting in increased wear. There is conflicting evidence regarding

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how alcohol-based mouthwashes affect the mechanical and physical properties of composite resins. This highlights the need for further research to clarify the effects of alcohol-containing mouthwashes on dental restorative materials.

The long-term performance of esthetic restorations can often be evaluated through surface roughness, a characteristic influenced by degradation and erosion from factors such as acidic or abrasive mouthwashes. Increased surface roughness may lead to plaque accumulation, discoloration, soft tissue irritation, and periodontal disease (6, 8, 9). Although alcohol can weaken composite resins, there is limited evidence on its effects on the surface roughness of composite restorations. This study aimed to examine the effects of immersion in an alcohol-containing mouthwash on the surface roughness of a nanohybrid composite resin.

Materials and Methods

This experimental laboratory study was conducted at the Faculty of Manufacturing Engineering, University of Surabaya, Indonesia.

Sample Preparation

This study used 27 cylindrical samples prepared from a nanohybrid composite resin (Filtek Z250 XT; 3M, Minnesota, USA).

For sample preparation, molds were made from cut insulin syringes measuring 4 mm in diameter and 2 mm in height. A celluloid strip was placed at the base of each mold, and the composite resin was inserted using plastic instruments. After filling, another celluloid strip was positioned on top, followed by a glass plate with a 1 kgF weight (Figure 1A) applied for one minute. Excess composite was removed using a dental explorer. Polymerization was performed with an LED light-curing unit (Woodpecker LED.B; Guilin Woodpecker Medical Instrument Co, Guilin, China) at an intensity of 400 mW/cm², positioned close and perpendicular to the sample surface for 20 seconds (Figure 1B). The samples were then polished sequentially with 600-, 1200-, and 2000-grit sandpaper disks and stored in distilled water at 37 °C for 24 hours.

Study Groups

The composite samples were divided into three groups (n=9) and underwent the following treatments:

Group 1: In this group, each composite block was immersed in 20 mL of an alcohol-containing mouthwash with a final alcohol concentration of 21.6%. The solution was prepared by mixing 6.2 mL of 70% ethanol with 13.8 mL of Listerine® Zero mouthwash (Johnson & Johnson, United States), resulting in a total volume of 20 mL.

Group 2: Each composite block was immersed in a solution prepared by diluting 13.8 mL of Listerine® Zero (Johnson & Johnson, United States) with 6.2 mL of distilled water.

Group 3 (control): Each composite block was immersed in a solution prepared by mixing 13.8 mL of saline with 6.2 mL of distilled water, resulting in a final volume of 20 mL.

In all groups, the samples were subjected to 12 cycles of 1-minute immersion in the respective mouthwash solutions per day. These cycles were performed once every hour. After each immersion, the samples were dried with absorbent paper and then placed in distilled water for 59 minutes in an incubator at 37°C. This procedure was repeated for 30 days, resulting in a total of 360 cycles (10).

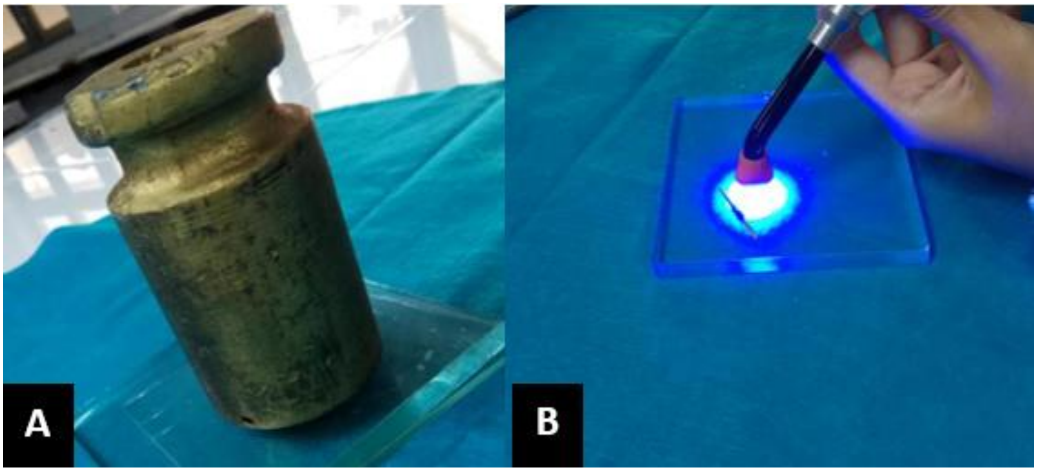

Figure 1. A) A weight scale (1 kgF) was placed on top of the glass slab for 1 minute, B) Composite resin curing with the LED Curing Unit for 20 seconds

Table 1. Mean values and standard deviations of surface roughness (µm) of nanohybrid composite resin after immersion in alcohol-containing mouthwash, non-alcoholic mouthwash, and saline

Groups			Mean ± SD
1	Alcoholic Mouthwash	Listerine® Zero	0.41 ± 0.12[a]
2	Non-Alcoholic Mouthwash	Listerine® Zero diluted with distilled water	0.29 ± 0.08[b]
3	*Saline* (Control)	Saline diluted with distilled water	0.29 ± 0.06[b]
P-value	0.01		

The groups with different lowercase letters have significant differences at P < 0.05.

Finally, all samples were removed, rinsed with 20 mL of distilled water for 120 seconds, and dried with absorbent paper (9).

Surface Roughness Assessment

The surface roughness (Ra) of nanohybrid composite resin samples was evaluated using a Mitutoyo SJ-201 surface roughness tester (Mitutoyo Corp., Japan). The instrument was calibrated according to the manufacturer's instructions before each measurement. A cut-off length of 0.25 mm and a tracing length of 2.5 mm were used to standardize the procedure. Ra, defined as the arithmetic average of the absolute deviations of the surface profile from the mean line, was used as the parameter for roughness evaluation. For each specimen, three measurements were taken at different, non-overlapping areas of the surface, and the mean value was calculated for the statistical analysis. All measurements were performed under identical laboratory conditions to ensure accuracy and reproducibility.

Statistical Analysis

The Kolmogorov-Smirnov test revealed that the data were normally distributed (P > 0.05). One-way ANOVA was run to determine any significant differences in surface roughness among the groups, followed by the Tukey HSD test for pairwise comparisons. The significance level was set at P < 0.05.

Results

Table 1 presents the mean and standard deviation (SD) of surface roughness values for the nanohybrid composite resin after immersion in 21.6% alcohol mouthwash, non-alcoholic mouthwash, and saline (control).

ANOVA revealed a significant difference in surface roughness (Ra) of the nanohybrid composite resin across the three treatment groups (P = 0.01). Post-hoc Tukey test indicated that the alcoholic mouthwash caused significantly greater roughness in the nanohybrid composite resin compared to the non-alcoholic mouthwash and saline solution (P < 0.05; Table 1).

Discussion

The present study investigated the effects of alcoholic and non-alcoholic mouthwashes on the surface roughness of a nanohybrid composite resin. Nanohybrid composites contain both microsized (0.4–0.5 µm) and nanosized (1–100 nm) filler particles, which improve their mechanical strength and esthetic properties (11). These properties make them popular for esthetic restorations where appearance and durability are critical.

In this study, immersion of composite resin specimens in the alcoholic mouthwash resulted in an average surface roughness of 0.41 ± 0.12 µm. In comparison, the non-alcoholic mouthwash and saline solution produced roughness values of 0.29 ± 0.08 µm and 0.29 ± 0.06 µm, respectively. Statistical analysis revealed that the surface roughness was significantly greater in the alcoholic mouthwash group than in the other study groups. This elevated roughness can potentially compromise the clinical performance of esthetic restoration by promoting surface degradation, increasing plaque accumulation and discoloration, as well as reducing wear resistance. These findings highlight the importance of considering the effects of alcohol in oral care products, as they have direct implications for the restoration's aesthetics and lifespan, and thus overall patient satisfaction.

Mouthrinses affect the surface roughness of resin composites in various ways, depending on their composition and the chemical structure of the composites. Alcohol, due to its dehydrating effect, can erode the composite surface, resulting in increased roughness (12). Furthermore, alcoholic mouthwashes contain both alcohol and water, which can degrade the polymer network and damage the siloxane bond at the filler-matrix interface (13). The polar groups in composite resins may attract alcohol and water into the resin matrix, pores, and filler interfaces, further contributing to surface changes (14). Overall, damage to siloxane bonds weakens the connection between fillers and silane coupling agents, facilitating crack formation and increasing surface roughness in composite materials (15-17).

In addition, water promotes hydrolysis of ester groups in the resin matrix, causing chain cleavage and producing degradation products that compromise resin integrity and hardness (18). Alcohols can also react with ester linkages through transesterification, but not necessarily causing the same hydrolytic chain scission as water (15). The polymer degradation exposes filler particles on the composite surface, further contributing to increased surface roughness (14).

This study found no significant difference in surface roughness between the non-alcoholic mouthwash group and the saline group. This may be because water is the main component of both solutions, which influences composite surface roughness. However, in alcoholic mouthwash, greater swelling of the polymer network occurs due to additional effects of alcohol exposure (19), leading to increased softening and a more pronounced reduction in wear resistance compared to saline or non-alcoholic mouthwash solutions.

The outcomes of this study are consistent with several previous studies. Yilmaz and Mujdeci (20) showed that alcohol-containing mouthrinses caused the greatest changes in the surface roughness of nanohybrid resin composites. Valizadeh Haghi et al. (21) reported that alcohol-containing Listerine caused more staining than chlorhexidine and two types of fluoride mouthwashes. This increased staining may result from the higher surface roughness caused by the alcohol in the mouthwash. de Moraes Porto et al. (22) reported that high alcohol concentrations can cause mechanical degradation and reduce the wear resistance of composite resins. Another study showed that drinks with 9% or more alcohol can soften the matrix, damage the polymer-filler interface, and increase wear (7). Urbano et al. (23) also noted that organic solvents like alcohol can degrade the polymer network over time.

In contrast to the outcomes of this study, Ayatollahi et al. (24) reported numerical increases in roughness with alcohol-based Listerine; however, these changes were not statistically significant. This variation may be due to differences in composite type (nanohybrid versus bulk-fill), mouthwash composition and alcohol concentration, and immersion duration and simulation methods between the studies.

This study has several limitations, including a small sample size and a short-term exposure period. Additionally, the study was conducted in vitro, and thus it cannot fully represent clinical conditions, including the effects of saliva and other oral factors. Further research should explore the effects of different alcohol concentrations in mouthwashes to clarify the dose-response relationship and its impact on surface roughness and mechanical properties of resin composites. Long-term studies are also suggested to evaluate the durability and performance of resin composites after prolonged exposure to various mouthwashes.

Conclusions

Under the conditions used in this study, exposure of resin composite to an alcohol-containing mouthwash caused significantly greater surface roughness as compared to the non-alcoholic mouthwash and saline solution. This increased roughness can potentially compromise the clinical performance of aesthetic restorative materials by promoting surface degradation and reducing wear resistance.

Acknowledgments

Not applicable.

Conflict of interest

The authors declare no conflict of interest.

Author contributions

P.A. designed and directed the project, performed the experiments and data curation, and drafted the manuscript. S.A. processed the experimental data, performed the analysis, and edited the manuscript. Both authors read and approved the final manuscript.

Ethical approval

Not applicable.

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