Examining The Influence of Mouthwashes on The Surface Texture and Color Stability of Dental Composites

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Abstract:

Background: This study investigates the potential effects of various mouthwashes on the surface roughness and color stability of dental composites, which can significantly influence the appearance and durability of the restorations. **Objective:** The aim of this research is to compare the surface roughness and color stability of Microfill and Nanofill dental composites after exposure to three distinct types of mouthwashes. **Materials and Methods:** A total of sixty specimens, each measuring 8 millimeters in diameter and 2 millimeters in thickness, were fabricated using nanofilled (3M ESPE / FiltekTM Z350 XT, A2/ USA) and microfilled (3M ESPE / Valux^{TM} Plus, A2/ USA) dental resin-based composites (RBCs). The specimens were polymerized using LED light and polished with EVE polishing discs to ensure uniformity. Three experimental groups were established to evaluate the effects of different mouthwashes. Surface roughness was evaluated using profilometer and color shifts were measured using a digital spectrophotometer, the CIELab colorimetric space was employed for analysis. The specimens were immersed in mouthwashes and synthetic saliva for varying durations each day, each cycle consisted of complete immersion in a mouthwash for 21 minutes (equivalent to 3 weeks of use) followed by immersion in saliva for 12 hours at 37˚C, this procedure was repeated eight times corresponding to six-month use of mouthwashes, surface roughness and colorimetric readings were re-analyzed. **Results:** The surface roughness values of the RBCs did not show a significant difference ($P > 0.05$) before and after immersion in mouthwashes. However, the ΔE values of both Microfill and Nanofill groups exhibited a significant difference before and after immersion ($P < 0.05$). **Conclusion:** The results of this study suggest that the three types of mouthwashes tested can indeed produce different effects on both types of dental composites. However, these effects were not found to be statistically significant. Notably, both Chlorhexidine and Enamel Protect exhibited a significant impact on the color stability of the composites, while Active Whitening showed only a minor influence.

Keywords: Mouthwash, Surface Roughness, Color Stability, Composite.

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Introduction

Dental composites have revolutionized restorative dentistry due to their ability to replicate tooth color and provide long-lasting, aesthetically pleasing dental restorations. Nanofilled and microfilled materials have developed as two separate varieties within the world of dental composites, each with its own set of features and benefits.[1] However, dental care agents such as mouthwashes may affect the surface features of these composites, including their roughness and color stability.[2,3]

Dental composites using nanoscale fillers, most often silica or zirconia nanoparticles, are known as nanofilled composites. These fillers' sub-100-nanometer particle sizes enable higher filler loading, which in turn boosts mechanical qualities including strength and wear resistance. The surface smoothness and aesthetic attractiveness of nanofilled composites are further improved by their high polishability. They are more resistant to surface roughness and discoloration over time, because the smaller filler particle size reduces the likelihood for plaque buildup and staining.[4,5]

Microfilled dental composites, on the other hand, have fillers with a greater range of sizes, often pulverized quartz or glass particles between 0.04 and 0.5 micrometers in size. Because of their remarkable resemblance to natural tooth structure in both translucency and opalescence, these composites are often used in anterior restorations where esthetic play a pivotal role.[6] Optimizing oral hygiene habits and choosing appropriate dental materials requires an awareness of the possible effects of mouthwashes on the surface roughness and color stability of nanofilled and microfilled dental composites. Because of their diverse chemical compositions, mouthwashes may have distinct effects on the composites. The utilization of mouthwashes can result in changes to the appearance of composites, affecting both their surface texture and color stability. These alterations are attributed to the active ingredients, flavoring compounds, and other constituents present in the mouthwash.[7,8]

When assessing the effectiveness of dental restorations, surface roughness is a crucial factor to take into account. The durability and aesthetic appearance of dental composites might be jeopardized by an increase in roughness, which can cause plaque buildup, discoloration, and bacterial adherence. The inclusion of ingredients like alcohol, antimicrobials, and flavorings in mouthwashes can potentially induce physical or chemical changes to the surface topography of composites.[9]

When assessing the longevity and aesthetic attractiveness of dental restorations, color stability is another important consideration. The oral environment, eating habits, and oral hygiene products like mouthwash are all potential threats to dental composites.[10] Absorption, adsorption, or chemical interactions between the composite matrix and the components in mouthwash may affect the color stability of composites. The color stability of dental composites is sensitive to environmental conditions such as pH, temperature, and length of exposure.[11-13]

This study aims to fill this gap in knowledge by examining how three different mouthwashes affect nanofilled and microfilled dental composites. By assessing changes in surface roughness and color stability, researchers can inform dental practitioners about the compatibility of these mouthwashes with various types of composites. This information will enable dentists to customize their recommendations for oral hygiene practices and dental materials, addressing the specific needs of their patients and maximizing treatment outcomes.

2. Materials and Methods

Nanofilled (3M ESPE / Filtek^{TM} Z350 XT, A2, Lot. Number: NE76519, USA) and Microfilled (3M ESPE / Valux^{TM} Plus, A2, Lot. Number: NE75726, USA) resin composites, were treated with three different mouthwashes (Chlorhexidine-based mouthwash, Active Whitening mouthwash, and Enamel protect Mouthwash). The research supplies are listed in (Table 1).

Table 1. Materials that used in the research.

Materials	Compositions
Chlorhexidine/ Wisdom, England, Bulgaria	Aroma, Limonene, Sodium Saccharin, Aqua, Glycerin, PEG-40 Hydrogenated Castor Oil, 0.2% Chlorhexidine Digluconate.
Active Whitening / Wisdom, England, Bulgaria	Aqua, PEG-40 Hydrogenated Castor Oil, Charcoal Powder, Aroma, Zinc Ricinoleate, Tetrasodium Glutamate Diacetate, Propanediol, Sodium Saccharin, Sodium Fluoride, 2-Bromo-2-Nitropropane-1,3-Diol, Eugenol, Limonene, Linalool.
Enamel protect/ Wisdom, England, Bulgaria	Aqua, Sorbitol, Glycerin, Potassium Citrate, PEG-40, Hydrogenated Castor Oil, Aroma, Sodium Fluoride, Citric Acid, Cetylpyridinium Chloride, Sodium Saccharin, 2-Bromo-2-Nitropropane-1, 3-Diol, Cl 18965, Cl 42051, Cinnamal, Eugenol. Contains: Sodium fluoride 0.10% w/w (450 ppm F)
Artificial Saliva / KIN/ Spain	Aqua, Peg-40 Hydrogenated Castor Oil, Xylitol, Sodium Saccharin, Sodium Methylparaben, Potassium Chloride, Aroma, Citric Acid, Potassium Phosphate, Menthol, Sodium Ethylparaben, Calcium Chloride, Sodium Chloride, 2-Bromo-2-Nitropropane-1, 3-Diol, Sodium Propylparaben, Potassium Thiocyanate, Magnesium Chloride.
Nanofilled (3M ESPE / FiltekTM Z350 XT, A2/ USA)	Filler ≤ 3um, 20 nm, 82% wt, matrix: Bis-GMA[1], Bis-EMA[2], UDMA[3], TEGDDMA[4]

Microfilled (3M ESPE / Valux™ Plus, A2/ USA)	Filler 66% by volume with a particle size range of 3.5 to 0.01 micron. Matrix: BIS-GMA and TEGDMA resins.

[1]Bisphenol A-glycidyl methacrylate. [2]Bisphenol A ethoxylated dimethacrylate. [3]Urethane dimethacrylate. [4]Triethylene glycol dimethacrylate

2.1. Specimen Preparations

These resin-based composites (RBC) were utilized to create disc-shaped specimens, with a diameter of 8 millimeters and a thickness of 2 millimeters.[14,15] 60 samples were produced from composites, with (30) from nanofilled and (30) from microfilled RBCs. A Glass slab was used to remove excess and uniform the surface. Following the manufacturer's recommendations, resin-based composites (RBCs) were polymerized using LED light (VALO Cordless, Ultradent Products, South Jordan, Utah, USA) with intensity of 1000 mW/cm2 for 20 seconds, for standardization a glass slide was used separating the curing tip from the specimens about 1mm. The samples were then polished in order to remove granulation using EVE polishing discs (ECOCOMP, RA 210, Germany). The samples were then packaged in clean containers to avoid drying out before undergoing the roughness and color stability tests.

2.2. Sample Grouping

For further testing with various mouthwashes, the two types of RBC specimens were split into three subgroups (n=10) for Chlorhexidine (Wisdom, England, Bulgaria), Enamel protect (Wisdom, England, Bulgaria), and Active Whitening (Wisdom, England, Bulgaria).

2.3. Baseline Roughness Test

The surface roughness of all specimens was carried out using profilometer (Taylor-Hobbson/Leicester, England, Uk). Three readings were taken with the distance (2.5mm) using a stylus tip in a speed of (0.5mm/second). The average of all three reading was taken for each sample.

2.4. Baseline Color Measurements

A digital spectrophotometer (Vita Zahnfabrik, Bad Sackingen, Germany) The measurements were taken using a white reference baseline and a standard illuminant in accordance with specifications established by the Commission Internationale d'Eclairage (CIELab). White-black (ΔL^*), red-green (Δa^*), and blue-yellow (Δb^*) color spaces are part of the three-dimensional CIELab system that was used to record the degree of color shift before immersion.[16]

2.5. Immersion Protocol

Specimens were immersed in mouthwashes and artificial saliva in cycles of daily dosing (20 mL) of tested mouthwashes for (21 minutes). Which is reported to be equivalent to (1minut) mouth rinse/ day for three weeks as recommended by the manufacturers. After that they were immersion in artificial saliva (KIN/ Spain) for 12 hours at 37°C. In order to simulate continuous usage for 6 months, this procedure was repeated eight times. Surface roughness and colorimetric measurements were repeated on the specimens at the conclusion of each cycle. Tristimulus values (ΔL, Δa, and Δb) from the CIELab color space were used to describe the color discrepancies which includes color spaces such as white-black (ΔL*), red-green (Δa*), and blue-yellow (Δb*). After that, we calculated how the following formula would rate the ΔE* colorimetric shifts.[17]

ΔE*ab =[(ΔL*)2 + (Δa*)2 + (Δb*)2]1/2

2.6. Statistical Analysis

SPSS (version 26 for Windows), a software program produced by (IBM in New York, NY, USA), was used to conduct the statistical analysis. The comparison of the mean values between groups for microhardness and color change (ΔE) was conducted using a non-parametric statistical hypothesis test, namely, the Wilcoxon test. The significance level was set at $p < 0.05$.

3. Results

The surface roughness of Microfill and Nanofill dental composites before and after exposure to various treatments is shown in Table 2 along with their respective means and standard deviations. When comparing RBCs before and after being submerged in mouthwashes, there were no statistically significant changes ($P > 0.05$).

Table 2: Surface roughness of microfill and nanofill RBCs, mean and standard deviation (nm) before and after immersion in mouthwashes.

Material	Microfill	Nanofill
Before Chlorhexidine	1.03130 ± 2.509569	0.27360 ± 0.071912
After Chlorhexidine	0.27900 ± 0.083991	0.25500 ± 0.052967
Before Active whitening	0.23170 ± 0.048279	0.23030 ± 0.096289
After Active whitening	0.29100 ± 0.079085	0.26200 ± 0.081894
Before Enamel protect	0.41570 ± 0.164762	0.23718 ± 0.050114
After Enamel protect	0.45400 ± 0.133350	0.25545 ± 0.064088

Table 3 displays the mean and standard deviations of ΔE for the Micro and Nanofill groups. Both composites showed significant difference ($P<0.05$) between them after inserting to mouthwashes. Chlorhexidine mouthwash had significant effect of ΔE of both composites. While, enamel protect showed higher color change of microfilled composite. However, in active whitening group ΔE values of both composites showed acceptable color changes $\Delta E \leq 3.3$.

Table 3: Mean and standard deviations of ΔE values of microfill and nanofill at the end of the immersion time in mouthwashes

Material	Microfill	Nanofill

	Mean ± Std. Deviations	Mean ± Std. Deviations
Chlorhexidine	7.03130 ± 2.509569	4.27360 ± 0.071912
Active whitening	3.23170 ± 0.048279	3.23030 ± 0.096289
Enamel protect	6.41570 ± 0.164762	3.23718 ± 0.050114

4. Discussion

The purpose of the research was to compare the impact of three popular brands of mouthwash (alcohol free) on the roughness and color retention of dental composites. Dental composites are commonly used in the dental profession due to their durability and ability to replicate natural teeth. However, the use of oral hygiene products such as mouthwash may have an impact on how well they perform in the future.[18] Surface roughness and color stability are crucial interrelated factors that contribute to the esthetic properties of dental restorations. The study's data led to a partial rejection of the null hypothesis. The results indicated that the immersion of RBCs in mouthwashes resulted in significant color changes in some groups, highlighting the potential impact of these mouthwashes on the esthetic aspects of dental composites.

In this study, color stability was measured using spectrophotometry, and surface roughness was measured using a profilometer, following the methodologies used in previous studies. The ΔE metric was utilized for evaluating small color changes, as it is a repeatable, sensitive, and objective method, allowing for precise and reliable assessment of color alterations in the dental composites.[18] Specimens were immersed in mouthwashes and artificial saliva daily for 1 minute, following the manufacturer's recommendations. Each cycle involved 21 minutes of mouthwash immersion (equivalent to 3 weeks of use) and 12 hours of artificial saliva immersion at 37°C. Artificial saliva was used to simulate the continuous washing effect of the oral cavity and to hydrate RBC specimens. This simulation was repeated 8 times corresponding to 6-month use of mouthwashes.[11] After that the surface roughness and colorimetric measurements were assessed to evaluate long-term effects on the composites.

When assessing the effectiveness of dental restorations, surface roughness should be taken into account. Plaque deposition, discoloration, and bacterial adherence may occur with increased roughness, reducing the durability and cosmetic appeal of dental composites. Mouthwash ingredients including alcohol, antibacterial agents, and flavoring additives might cause topographical changes to the composite surface by chemical or mechanical means.[19]

The Microfill composite exhibited a mean surface roughness of 1.03130 ± 2.509569 before exposure to Chlorhexidine, while the Nanofill composite had a mean surface roughness of 0.27360 ± 0.071912. After treatment with Chlorhexidine, the surface roughness of Microfill decreased to 0.27900 ± 0.083991, and the Nanofill composite reduced to 0.25500 ± 0.052967. These results indicate that Chlorhexidine reduced the roughness of both types of composites. These findings are consistent with previous researches, which also demonstrated the impact of Chlorhexidine on the surface roughness of dental composite materials. They concluded that Dental composites' durability and aesthetic appeal may be improved by using Chlorhexidine mouthwash, which may reduce the roughness of the composites' surfaces.[20,21] Moreover, Microfill composite's mean surface roughness before Active Whitening treatment was 0.23170± 0.048279, and it remained essentially stable after exposure to 0.29100±0.079085, Nanofill composite's mean surface roughness was 0.23030 ±0.096289 before and after immersion, to a slight change 0.26200 ±0.081894. These findings suggest that Active Whitening had a negligible effect on the composites' surface roughness.

However, compared to the Nanofill composite's roughness of 0.23718 ±0.050114, the Microfill composite's roughness was 0.41570 ±0.164762 before being treated with Enamel Protect. After being exposed, the surface roughness of both Microfill and Nanofill rose to 0.45400 ±0.133350 and 0.25545 ±0.064088, respectively. In particular, the Microfill composite seems to have seen an increase in surface roughness as a result of being treated with Enamel Protect. Previous research has demonstrated that using a mouthwash may affect the surface roughness of dental composites[22,23], which is in agreement with current study findings. Additionally, Yeh et al., found that fluoride can cause degradation of the composite resin matrix and fillers.[24]

Color stability and surface texture are key factors that dental professionals prioritize when choosing esthetic materials for dental restorations. Maintaining long-term color consistency ensures aesthetically pleasing results, different instruments and techniques can be used to estimate discoloration. The Commission Internationale de l'Eclairage (CIE L*, a*, b*) system was selected for this particular study to assess chromatic differences. In this system, L* represents the sample's lightness, a* denotes the green-red axis (negative values indicate green, positive values indicate red), and b* describes the blue-yellow axis (negative values represent blue, positive values represent yellow). To encompass changes in L*, a*, and b*, the total color change (ΔEab) can be calculated. Various studies establish different thresholds for color differences that are noticeable to the human eye. However, in the context of dental materials, it is generally considered acceptable for the color change to be $\Delta Eab \leq 3.3$.[25,26]

The purpose of this research was to examine how various mouthwashes affected the durability of dental composites' color. Chlorhexidine's mean color stability (ΔE) was 7.03130±2.509569 for the Microfill composite, whereas it was just 4.27360 ±0.071912 for the Nanofill composite. These results indicate that Chlorhexidine significantly affected the composites' color stability. These findings are consistent with previous research Khosravi et al., found that Chlorhexidine mouthwash had a substantial effect on the color stability of nanofilled and microhybrid resin-based composites.[19] Furthermore, a study published in 2016 by Baig et al. demonstrated that nanofilled resin composite restorative material had a maximum color change. This color change was attributed to the usage of chlorhexidine-containing mouthrinses containing 0.2% chlorhexidine gluconate, which were discovered to affect the color stability of resin composites.[27] Chlorhexidine is a chromogenic biguanide that causes brown discoloration of teeth, tongues, silicate restorations, and resin restorations.[28,29] Chlorhexidine has been reported to stain by a variety of mechanisms, including chlorhexidine breakdown to produce parachloraniline, non-enzymatic browning (the Maillard reaction), metal sulfide generation by chlorhexidine, and cationic antiseptic precipitation of anionic dietary chromogens.[30,31] These findings in a accordance with previous studies conducted by Celik et al. in 2008,[32] and Poggio et al.,[33] and others.[34,35]

However, in Active Whitening, Microfill composite showed a mean color stability of 3.23170 ±0.48279 and Nanofill composite showed a mean color stability of 3.23030 ±0.096289. These findings suggest that Active Whitening had a small effect on the composites' color change. concerns have been raised regarding the potential adverse effects of charcoal on resin composite or ceramic restorations. A study reported that accumulation of charcoal within the gingival sulcus or margins of restorations can lead to a dark gray color, necessitating replacement of these materials for esthetic reasons.[36] However, it is important to note that the results of the present study, which demonstrated that charcoal-containing mouthwashes had no or minimum effect on composite color changes this may be due to its stain removing ability.[37] Consequently, the color change exhibited by active whitening was not visually perceptible.[26] The average color retention of Microfill composites with Enamel Protect was 6.41570 ± 0.164762, while the average color retention of Nanofill composites was 3.23718 ± 0.050114. These results show that using Enamel Protect mouthwash had a substantial impact on the color stability of the Microfill composite.[38]

Dental professionals should exercise caution when selecting mouthwashes to minimize their potential impact on the surface roughness and color stability of dental composites. Choosing dental materials with excellent esthetic and durability characteristics is crucial for successful restorations.

5. Conclusion

These results indicate that the surface roughness of dental composites may not be significantly affected by the mouthwash type. Dental composites' color stability was much changed by Chlorhexidine and Enamel Protect, but Active Whitening had a little effect. These results have significant repercussions for dental practice since color stability is a crucial consideration when evaluating the aesthetic attractiveness of dental restorations.

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