RESEARCH PAPER

Evaluation Of Colour Stability And Surface Microhardness Of Nano-Enhanced Composite Resins When Combined With Whitening Mouthwash

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ABSTRACT

Aims and Objective: To Evaluate & Compare the Colour change & Surface Microhardness of Nanoenhanced composite resin after using whitening mouthwashes.

Study Design And Settings:

Forty disc-shaped specimens were prepared using two A2-shade nano-enhanced composites (FGM Vittra APS and Coltene Brilliant EverGlow). Specimens were stained in coffee to simulate extrinsic discoloration, followed by immersion in whitening mouthwashes to assess effects on color stability and surface microhardness.

Materials and Methods:

Specimens were divided into two groups (n=20 each) based on composite type. After 15 days of coffee staining, baseline color (CIE L*a*b*) and microhardness (Vickers test) were recorded. Each subgroup group was then immersed in Perfora Whitening or Activated Charcoal mouthwash for 24 hours. Post-immersion, color change (ΔE) and microhardness were reassessed.

Statistical analysis used: Data were analyzed using SPSS. Normality was tested with Shapiro-Wilk. One-way ANOVA with Bonferroni and paired t-test were used; significance at $p<0.05$.

Results: All the samples showed colour & surface microhardness to varying degrees. Whitening mouthwash caused greater discoloration; FGM vittra APS showed higher hardness than Coltene brilliant everglow with charcoal mouthwash preserving color stability best.

Conclusions: The utilization of whitening mouthwash markedly diminished the color stability, especially in the context of FGM Vittra APS. The application of charcoal mouthwash resulted in reduced discoloration without adversely affecting hardness.

Key-words: Perfora Whitening mouth wash, Perfora charcoal mouth wash, Fgm Vittra APS, Coltene brilliant everglow ,Nanoenhanced composite , surface microhardness, colour stability

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INTRODUCTION

Dental aesthetics play a crucial role in modern restorative dentistry, where advancements continually strive to meet the dual objectives of functional integrity and visually pleasing outcomes. Among the various materials developed to fulfill these demands, nanohybrid and nanofilled composite resins have emerged as leading alternatives due to their superior mechanical properties and enhanced esthetic performance, largely attributed to nanoscale filler technology [1.]

Nanohybrid composites incorporate a mixture of nano-sized particles and larger hybrid fillers, providing an optimal balance between mechanical strength and esthetic quality. This makes them highly suitable for both anterior and posterior restorations . Earlier-generation hybrid composites, composed of macrofilled and microfilled particles—with macro components ranging from 15–20 µm and colloidal silica particles as small as 0.01–0.05 µm —offered improved wear resistance and polishability[2] . More recently, nanohybride composites have been developed using advanced nanotechnology, incorporating zirconium/silica and nanosilica fillers with particle sizes down to 25 nm and agglomerates around 75 nm. These fillers are typically silanized to enhance their bond with the resin matrix. This innovation has allowed for higher filler loading (up to 79.5%), resulting in reduced polymerization shrinkage, improved mechanical durability, and better long-term clinical outcomes[3] .

One of the fundamental properties affecting the longevity and clinical success of composite restorations

*Author for Correspondence: : sonalitaneja@its.edu.in is surface microhardness, which directly correlates with a material's resistance to wear, abrasion, and fracture under occlusal forces[1]. However, surface irregularities and roughness can compromise these benefits by increasing susceptibility to extrinsic staining and discoloration.

Discoloration of composite resins is a multifactorial issue, influenced by both extrinsic factors, such as dietary intake, and intrinsic factors, including the resin matrix composition and polymerization efficiency. Among extrinsic factors, dietary substances—notably coffee, tea, red wine, carbonated beverages, and deeply pigmented foods like berries, curry, and tomato-based sauces—are well-documented contributors to staining [4,5]. Coffee, in particular, poses a significant challenge due to its high levels of chromogens and tannins, which bind to the resin surface and cause progressive discoloration . Its acidic nature may further degrade the resin matrix, exacerbating stain penetration.

Intrinsic factors, such as a higher resin content, filler type, and surface roughness, also impact stain susceptibility. Composite materials with greater surface roughness or lower filler content often retain more stains, making the selection of restorative material a key consideration in esthetically demanding cases [6,7]

Given the growing demand for long-lasting aesthetic restorations, the assessment of color stability has become an essential aspect of restorative material evaluation. The spectrophotometer, which quantifies color changes using the CIELAB color space (L*, a*, b* values), is regarded as one of the most precise tools for this purpose[7]. This method allows for objective, reproducible analysis of color variation due to staining agents, hygiene products, or environmental exposure, and is widely adopted in both laboratory and clinical studies [6].

In addition to dietary influences, oral hygiene products, particularly mouthwashes, can affect the esthetic and mechanical integrity of composite resins. While mouthwashes are commonly used for their antibacterial and anti-plaque benefits, their chemical compositions—especially those containing alcohol or acidic agents—may alter the surface characteristics of restorative materials[8,9]. The rising popularity of whitening mouthwashes and charcoal-based oral care products has prompted concerns regarding their potential effects on the durability and color stability of composites[9]. Although marketed for their whitening capabilities, these products often lack sufficient clinical evidence to support their long-term safety and efficacy .

Despite their widespread use, limited research has focused on how various mouthwash formulations affect nanohybrid composites, particularly in terms of surface microhardness and staining behavior.

Given the increasing use of aesthetic restorative materials and consumer oral hygiene products, there is a pressing need to investigate their interactions. This study aims to evaluate the effects of commonly used mouthwashes, especially those with whitening agents, on the color stability and microhardness of nanohybrid composite resins. Through spectrophotometric analysis, this research will provide objective, quantitative insights into how these materials respond to oral hygiene products and dietary staining agents. The findings will inform material selection and clinical recommendations to optimize the longevity and aesthetic performance of composite restorations.

Null hypothesis states that

1. There is no difference between colour change of composite with charcoal & whitening mouthwashes
2. There is no difference in colour change of Fgm vittra APS and Coltene Brilliant everglow
3. There is no difference between microhardness of composite on interaction with charcoal & whitening mouthwash
4. There is no difference between microhardness of Fgm vittra APS and Coltene Brilliant everglow.

MATERIAL AND METHOD :

Specimen Preparation

Two different composite group with A2 shade was used to prepare total 40 disc-shaped specimens with stainless steel moulds with dimensions of 8 mm in diameter and 2 mm in thickness. Following the placement of the resin composite into the mould, each specimen was covered with a transparent celluloid (Mylar) strip and a glass plate. Light pressure was applied to eliminate excess material and achieve a smooth surface finish. Polymerization was carried out in accordance with the manufacturer's instructions, using a light-emitting diode (LED) Bluephase N- Ivoclar Viadent, USA) for 20 seconds. To standardize the distance between the light source and the specimen, a 1 mm thick glass slide was placed over the mould during curing. Following light curing, both sides of each specimen were polished using the Shofu Composite Polishing Kit. The polished specimens were then stored in distilled water at 37 °C for 24 hours to allow for post-polymerization.

Coffee staining

Coffee solution was prepared by dissolving 1 teaspoon of Nescafe classic, India, in 200 mL of boiling water. All specimens were stored at 37 °C for 15 days in incubator. Previous studies indicate that an average coffee consumer drinks around 3.2 cups per day, taking approximately 15 minutes to consume each cup. Based on this consumption pattern, 24 hours of immersion in coffee simulates roughly one month of intake. Therefore, a 15-day immersion period is equivalent to approximately 1.3 years of daily coffee consumption. After the immersion period, specimens were removed , rinsed under running water for 10 seconds to simulate the cleansing action of saliva, and then air-dried to standardize the samples[10-13]

Spectrophotometer analysis & surface microhardness testing after staining

Reflectance spectrophotometer was used for spectrophotometric analysis for each sample. The reflectance spectrum for the measured samples were used to calculate the CIE XYZ coordinates using a builtin software. A 100% reflectance calibration was undertaken before each measurement to reduce possible instrumental drift. The CIE XYZ data was then imported into a spreadsheet (Microsoft Excel) and the X, Y and Z colour tristimulus values converted to CIELAB colour coordinates.

The baseline microhardness of each specimen was noted. The mean Vickers hardness number (VHN) measurements of each surface of the composite resin disc were performed by three randomly performed diamond indentations (2 µm in diameter). A microhardness tester (S.M,Scientific Instrumets, India) was used at 30 N (300 gf) for 10 s. The formula used to calculate VHN is as follows: HV = 1.854·F/d2 where F is the applied force in kgf and d is the average diagonal length in mm. After baseline measurement, the samples were immersed in different mouthwashes.[14,15]

Immersion of disc into mouthwash group

For this study, we have taken two mouthwashes: Teeth whitening mouthwash (Perfora, india) and Activated charcoal mouthwash (Perfora, india). Almost the equivalent of two minutes of daily rinsing for two years, each specimen was submerged in 20 ml of chosen mouthwashes for 24 hours at 37°C in an incubator . [8,9]

Spectrophotometer analysis & surface microhardness testing after impression in mouthwash

The sample were removed from mouthwashes & left to air dry at room temperature. Spectrophotometer analysis & surface microhardness repeated as above. The experiment were conducted by trained dental professionals.

STATISTICAL ANALYSIS

Statistical Methods: Statistical analysis was done by Statistical Package for the Social Sciences (SPSS) software package (SPSS 16 Inc, Chicago IL, USA). The normality of data was tested by Shapiro Wilk's test. The values obtained was statistically analyzed and to compare the parameters between groups and within groups for normal data parametric test one way ANOVA followed by Bonferroni test, for intra group paired t-test was used among the study population. The level of significance and confidence interval was 5% and 95% respectively, i.e., p< 0.05.

*Significant p<0.05,
** Highly significant p<0.01
*** Very highly significant p<0.001
^{NS} not significant p>0.05

RESULTS:

The Table 1 and Graph 1 showed change in Delta E of both the composite after each mouthwash use ,.In all the groups tested Whitening mouthwash (B) causes significantly more color change than charcoal (A).FGM composite with whitening shows the most discoloration. **Highest ΔE** change in Group 1B ie in FGM + Whitening mouthwash group .**Lowest ΔE** change in Group 1A ie,FGM + Charcoal group

The Table 2 and Graph 2 showed changes in Microhardness of both the composite after each mouthwash use, in all the groups tested Composite material affects hardness significantly..FGM Vittra is significantly harder than Coltene Brilliant EverGlow ..Both of the mouthwash does not significantly affect hardness. **Highest VH** in Group 1A ie ,FGM + Charcoal mouthwash group.**Lowest VH** in Group 2B ie, Coltene + Whitening mouth wash group

DISCUSSION

The rising demand for esthetic restorations has driven attention to the performance of resin composites under common challenges such as staining and at-home whitening. Nanohybrid composites, characterized by a blend of nano- and micro-sized fillers, are engineered for optimal mechanical and esthetic performance. In this study, two advanced nanohybrid materials—FGM Vittra APS and Coltene Brilliant EverGlow—were investigated for their color stability and microhardness after exposure to coffee staining and subsequent treatment with over-the-counter (OTC) whitening and charcoal mouthwashes.

FGM Vittra APS incorporates an advanced polymerization system designed to improve depth of cure and gloss retention[16,17] while EverGlow offers long-term polishability and wear resistance through its reinforced matrix and spherical fillers[18,19] The selection of these materials aligns with clinical trends and prior literature emphasizing the importance of filler morphology, matrix composition, and polymer network density in determining a composite's resistance to staining and chemical degradation [2 ,21]

Color stability remains a significant challenge in composite restorations. Discoloration may result from intrinsic factors like polymer matrix degradation or from extrinsic sources such as food, beverages, and oral care products[22,23]. Coffee, a known chromogen, was chosen as the staining agent due to its high staining potential linked to its polyphenolic content and low pH[24,26]. A 15-day coffee immersion simulated long-term clinical exposure, followed by rinsing in distilled water to replicate oral hygiene, consistent with protocols that reduce pigment retention[24].

Following staining, specimens were treated with Perfora Charcoal or Whitening mouthwash for 24 hours at 37 °C—approximating two years of daily two-minute usage. The whitening product, containing hydrogen peroxide, leverages oxidative mechanisms to decolorize organic pigments. However, reactive oxygen species may also degrade polymer chains and resin-filler interfaces [27,28]. Conversely, charcoal-based products act primarily through mechanical adsorption and abrasion, posing different challenges for surface preservation [24].

Color change (ΔE) analysis showed the highest shift in Group 1B (Vittra + Whitening, ΔE = 9.21 ± 1.7), followed by Group 2B (EverGlow + Whitening, ΔE = 8.30 ± 1.53), with the lowest in Group 1A (Vittra + Charcoal, ΔE = 5.14 ± 2.3). These differences were statistically significant (p = 0.001). Whitening-induced bleaching caused an increase in L* values and a slight blue shift, confirming oxidative degradation. These findings align with previous reports linking peroxide treatment to pronounced esthetic improvement, often at the cost of surface quality [27]

The whitening group also demonstrated significant reductions in surface microhardness. Vickers Hardness Number (VHN) values decreased most in EverGlow specimens, with Group 2B measuring 31.4 compared to 59.3 in Group 1B (Vittra + Whitening). Charcoal groups retained higher VHN values, particularly Vittra (61.5 in Group 1A), suggesting less matrix disruption. These outcomes support earlier studies highlighting the susceptibility of composites to peroxide-induced matrix softening, filler debonding, and silane layer degradation Material-specific responses further clarified these findings. Vittra APS showed higher overall hardness due to its photoinitiator-enhanced polymerization and densely silanized fillers[17]. However, its hydrophilic resin components (e.g., Bis-EMA, UDMA) may facilitate greater peroxide diffusion, increasing susceptibility to oxidative degradation[29 30]. In contrast, EverGlow's matrix, with a balanced mix of Bis-GMA, UDMA, and TEGDMA, and its spherical filler architecture, appeared more resistant to surface erosion but showed greater discoloration [31]

Although charcoal exposure resulted in lower ΔE values, microhardness reductions still occurred, indicating that mild abrasiveness may affect surface properties[32]. EverGlow's slightly better hardness retention under charcoal exposure is likely due to its denser filler distribution and superior resin-filler bond integrity. This observation is consistent with findings by Ilie and Hickel [33], who reported that composites with compact, uniformly distributed fillers exhibit enhanced resistance to wear and chemical degradation.

Clinically, the results underscore the importance of considering both the composition of composite resins and the nature of OTC mouthwashes. Whitening mouthwashes may yield rapid esthetic results but pose a risk to the structural integrity of certain composites, particularly those with hydrophilic matrices or exposed filler interfaces. Charcoal-based products, while less aggressive chemically, may still cause long-term surface roughness, potentially increasing biofilm retention and secondary discoloration.

While the study employed clinically relevant immersion protocols and widely available OTC products, limitations include the absence of dynamic oral conditions such as brushing, saliva, and enzymatic activity. Moreover, surface topography changes were not visualized microscopically. Future studies incorporating in vivo conditions and microscopic analysis are warranted to expand on these findings.

CONCLUSION

Whitening mouthwash significantly improved color but compromised surface hardness, especially in FGM Vittra APS. Charcoal mouthwash showed a milder impact on both color and hardness, suggesting better compatibility with composite restorations. Material-specific formulations—particularly filler distribution and resin chemistry—strongly influenced outcomes. Clinicians should evaluate both patient hygiene preferences and composite material characteristics when advising on OTC mouthwash use, balancing esthetic goals with long-term restoration durability.

CONFLICT OF INTEREST- Nill
FINANCIAL DISCLOSURE- No financial support

Key Messages: This study reveals that whitening mouthwash enhances stain elimination but decreases surface microhardness, while charcoal mouthwash maintains microhardness effectively. Material composition and filler properties influence color stability and mechanical resistance.

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Table 1. Multiple Comparisons of ΔE Between Study Groups

Dependent Variable	**(I) Group**	**(J) Group**	**Mean Difference (I–J)**	**Std. Error**	**p-value**	**95% Confidence Interval**
ΔE	Group 1A	Group 1B	–4.0717*	1.0453	.002	–6.990 to –1.153
		Group 2A	–0.7318	1.0453	1.000	–3.650 to 2.187
		Group 2B	–3.1605*	1.0453	.028	–6.079 to –0.242
	Group 1B	Group 2A	3.3398*	1.0453	.017	0.421 to 6.258
		Group 2B	0.9112	1.0453	1.000	–2.007 to 3.830
	Group 2A	Group 2B	–2.4286	1.0453	.156	–5.347 to 0.490

* *The mean difference is significant at the 0.05 level.*

Table 2. Multiple Comparisons of Vickers Hardness (VH) Between Study Groups

Dependent Variable		(I) Group	(J) Group	Mean Difference (I–J)	Std. Error	p-value	95% Confidence Interval
VH		Group 1A	Group 1B	2.2400	2.2488	1.000	–4.039 to 8.519
			Group 2A	28.8740*	2.2488	.000	22.595 to 35.153
			Group 2B	30.1180*	2.2488	.000	23.839 to 36.397
		Group 1B	Group 2A	26.6340*	2.2488	.000	20.355 to 32.913
			Group 2B	27.8780*	2.2488	.000	21.599 to 34.157
		Group 2A	Group 2B	1.2440	2.2488	1.000	–5.035 to 7.523

** The mean difference is significant at the 0.05 level.*