Print ISSN: 2321-6379
Online ISSN: 2321-595X

Original Article

Color Stability and Staining Susceptibility of Nanohybrid Composite after Treatment with two Different Bleaching Agents: An *in vitro* Study

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Abstract

Aim: The study aims to evaluate the color stability and staining susceptibility of the nanohybrid composite after treatment with two different bleaching agents - carbamide peroxide and hydrogen peroxide (HP).

Materials and Methods: The test materials included a nanohybrid composite, two bleaching agents, and a staining solution. Thirty-six disc-shaped specimens of the nanohybrid composite were fabricated and divided into the control group (no bleaching), group A bleached with carbamide peroxide, and group B bleached with HP. Specimens were then immersed in a tea solution over 3 h. The color of each specimen was measured and expressed by CIELAB system using a spectrophotometer, and the surface roughness was measured using profilometer. The color stability and surface roughness of groups A and B were compared with group C. The data were analyzed using a one-way analysis of variance. A $P = 0.05$ or less was considered to indicate statistical significance.

Results: Statistically significant difference in the surface roughness and significant discolouration were found in the samples treated with the two bleaching agents and the difference between the two groups were also significant.

Conclusion: The home bleaching with 20% carbamide peroxide and the in-office bleaching with 30% HP showed a significant change in color stability and staining susceptibility of the nanohybrid composite.

Key words: Bleaching agents, Nanohybrid composite, Color, Surface roughness, Tea

INTRODUCTION

Nowadays, the use of products for bleaching vital teeth has grown significantly. Hydrogen peroxide (HP) and carbamide peroxide are the commonly used bleaching agents. Home bleaching makes use of a bleaching agent at a low concentration, such as carbamide peroxide. The in-office system of bleaching uses bleaching agents at higher concentrations like HP. HP, in concentrations ranging from 3% to 40%, is the most commonly used bleaching agent. It decomposes into hydroxyl-free radicals, which dissociate double bonds or ring structures within stains. Bleaching efficacy is typically attributed to several factors within the bleaching protocols, such as activation sources, HP concentration, bleaching duration, and the structure of restorative materials. This encompasses the structure of the resin matrix and the characteristics of the filler particles.[1]

The higher the concentration of HP, the more effective the depigmentation process, leading to stain removal and color changes in resin-based composites. While the effects of HP on the color change of resin-based composites are still debated, it is generally accepted that various types of resin-based composites exhibit different levels of resistance to bleaching.[2]

Bleaching can lead to changes in microhardness and roughness. An increase in surface roughness tends to promote biofilm formation and extrinsic staining.[3]

Access this article online

www.ijss-sn.com

Month of Submission : 03-2025
Month of Peer Review : 04-2025
Month of Acceptance : 05-2025
Month of Publishing : 05-2025

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The surface texture of dental materials significantly impacts plaque accumulation, discoloration, wear, and the esthetic appearance of both direct and indirect restorations. Moreover, a smooth surface enhances patient comfort, as the tip of the tongue can detect changes in surface roughness as small as 0.3 μm.[4]

The purpose of the present study was to evaluate the color stability and staining susceptibility of the nanohybrid composite after treating with two different bleaching agents, i.e., 20% carbamide peroxide and 30% HP.

The null hypothesis states that there is no significant change in the color stability and staining susceptibility of nanohybrid composite after treating with two different bleaching agents.

MATERIALS AND METHODS

Nanohybrid composite (Shofu, beautiful II, of shade A2), one staining solution (tea), and two bleaching agents (ultradent opalescence PF 20% and Florence in-office whitening system) were evaluated in the present study. 36 disc-shaped specimens of nanohybrid composite were fabricated of size 10.5 mm × 1.5 mm using a silicon impression mold. The resin composites were placed into the mold, covered by a mylar strip polymerized with a light-emitting diode unit (Bee Cool LED) for 40 s with a light intensity of 1,100 mW/cm^2. The composite discs were divided into 3 groups with 12 in each.

The three groups include;
1. Control group (C) – no bleaching performed
2. Group (A) – Samples treated with ultradent opalescence PF 20%
3. Group (B) – Samples treated with Florence in-office whitening system.

Groups A and B were subjected to their respective bleaching agents. A 2 mm thick layer of bleaching agent was brushed on top of the composite discs.

In group A, 6 h was the assigned bleaching time. The samples of group B were bleached in three sessions, each session was held for 10 min. After each bleaching session, specimens were cleaned with distilled water for 30 s and stored in artificial saliva until the next bleaching session. Samples in group A, B, C were then placed in a container with 10 mL for 3 h, which were prepared by mixing 4 g of dry tea (AVT premium tea) added to 500 mL of boiling water, and brewed for 4 min.

The solution was then allowed to cool to room temperature. The color of each specimen was measured and expressed by CIELAB system using a Spectrophotometer, and the surface roughness was measured using a Profilometer. The color stability and surface roughness of group A and B were compared with group C.

RESULTS

One-way analysis of variance revealed that the bleaching agent application affected color stability in groups A and group B ($P < 0.01$). The difference between the two groups was also statistically significant. Concerning surface roughness, there was a highly significant change in the surface roughness in group A and group B ($P < 0.001$). The difference between the two groups was also statistically significant. In the present study, $\Delta E = L^*a^*b^*$ values higher than 3.3 were interpreted as visually perceptible and clinically unacceptable.

The surface roughness expressed as Roughness average (Ra) expressed in μm was more for the samples treated with Florence in office bleaching system followed by the ultradent opalescence PF home bleach in comparison with the control group. Statistically significant difference in the surface roughness was found in the samples treated with the two bleaching agents, and the difference between the two groups was also significant [Table 1].

The amount of discoloration was more in the samples treated with Florence in office bleach, followed by the Ultradent opalescence PF in comparison with the control group. Statistically significant discoloration was found in the samples treated with the two bleaching agents, and the difference between the two groups was also significant [Table 2].

DISCUSSION

Dental bleaching has become a popular treatment in dental clinics to enhance dental esthetics. However, during both in-office and at-home bleaching procedures, it is challenging to prevent bleaching gels from coming into contact with all restorations.[5]

The present study evaluated the influence of 30% HP and 20% carbamide peroxide on color difference and stain susceptibility of the resin-based composites.

In the oral environment, stain resistance of resin-based restorations is crucial to protect against common external factors like food and drink, which can cause discoloration of these restorative materials.

The color stability of a resin composite material is influenced by several chemical factors within its resin

Table 1: Surface roughness

Groups	Mean	SD	F-value	P-value
Control	0.062[a]	0.009		
Opalescent	0.087[b]	0.015	57.12	<0.001**
Florescent	0.650[ab]	0.078		

*p-value <0.05 is statistically significant; **<0.001 is statistically highly significant.

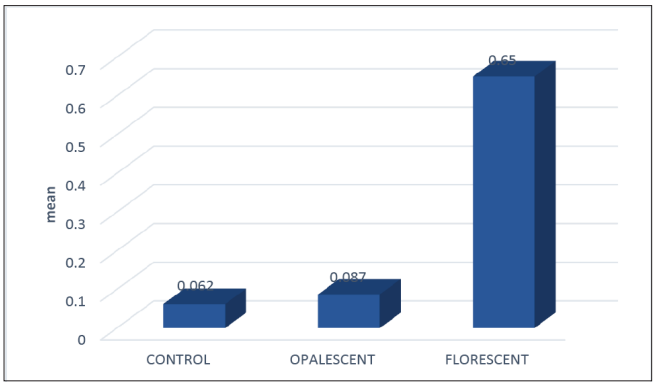
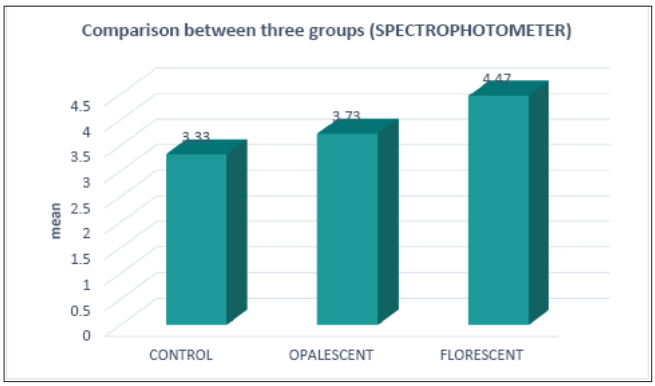


Table 2: Color stability

Groups	Mean	SD	F-value	P-value
Control	3.33[ab]	0.23		
Opalescent	3.73[ac]	0.26	33.09	<0.001**
Florescent	4.47[bc]	0.45		

*p-value <0.05 is statistically significant; **<0.001 is statistically highly significant.



components. These factors include the purity of oligomers and monomers, the concentration and type of activators, initiators, and inhibitors, the oxidation of unreacted carbon-carbon double bonds, the amount of filler, and the color of the inorganic pigments.

In resin compositions, a high proportion of bisphenol A glycidyl methacrylate, which contains hydrophilic hydroxide groups, results in greater water absorption and increased susceptibility to staining compared to those with a high proportion of urethane dimethacrylate.[6]

Nanohybrid resin composites are highly popular because they combine nanoparticles with submicron particles, improving filler distribution in the matrix. This results in enhanced mechanical, chemical, and optical properties.[1]

Although there is extensive literature on the effects of various sealants, bleaching agents, polishing agents, and juices on the surface roughness and color stability of nanohybrid composites, there is limited research on the impact of commonly consumed beverages like tea, coffee, and Coke.

As per the Tea Board of India, about 80% of the tea produced in the nation is consumed locally.[7] The yellow-red polyphenol pigments in black tea have been reported to cause notable staining in hybrid resins.[8]

The discoloration of the composite was measured using the CIELAB system, with ΔE calculated as $\Delta E = \sqrt{([L1^*–L2^*]^2 + [a1^*–a2^*]^2 + [b1^*–b2^*]^2)}$. In this system, L* indicates lightness on a scale from 0 (dark) to 100 (bright), a* denotes the red-green axis, and b* represents the yellow-blue axis.[9,10] All groups had a ΔE value >3.3, with samples treated with 30% HP exhibiting the most significant color change.

Surface roughness was assessed using the Ra value, which represents the arithmetic average height of surface irregularities from the mean line over the sampling length.[11] A restoration is considered optically smooth if its surface Ra value is below 0.1 μm.[12]

In the present study, the samples treated with 30% HP showed the highest value compared to other groups.

HP acts as a potent oxidizing agent, leading to the leaching of unpolymerized monomers and diverse oxidative by-products from composites. Interaction with the carbon-carbon (C-C) bonds in the composite polymer enhances the release of these unpolymerized monomers and nonspecific oxidative substances.[5,13]

Achieving complete polymerization of resin-based composites remains a persistent challenge. A lower conversion rate in these composites results in increased elution of residual monomers. The properties of resin-based composites are significantly impacted by the chemical structure of the matrix phase. In terms of clinical esthetic failures, pigmentation or color alteration is frequently cited as a primary reason for replacing esthetic dental restorations.

Maintaining excellent esthetic properties requires composite restorations to exhibit strong color stability. In the oral environment, esthetic restorations are exposed to factors such as light, moisture, oral habits, and dietary patterns such as caffeine consumption, which can induce

external pigmentation. Moreover, intrinsic factors such as organic matrix hydrolysis and inadequate silanization leading to the loss of inorganic particles can also contribute to chromatic alterations in restorations.[5]

One limitation of the current study is that it does not assess how different polishing systems affect changes in surface roughness. In addition, the patient's diet and oral hygiene can also influence the color stability of composite restorations. For instance, the contact of food and liquids during eating can induce surface roughness in composite restorations, a factor not addressed in this study.

CONCLUSION

Within the limitation of the study, the bleaching treatment with 30% HP and 20% carbamide peroxide showed significant surface roughness and color change. The in-office whitening system with 30% HP showed the highest surface roughness and discoloration compared to home bleaching with 20% carbamide peroxide. These changes are attributed to the percentage concentration of HP.

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How to cite this article: Simon EP, Belaram K, Raveendran C, Mathews N, Kurian N. Color Stability and Staining Susceptibility of Nanohybrid Composite after Treatment with two Different Bleaching Agents: An *in vitro* Study. Int J Sci Stud 2025;13(2):25-28.

Source of Support: Nil, **Conflicts of Interest:** None declared.