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EFFECT OF HYDROGEN PEROXIDE ON THE COLOR STABILITY AND ROUGHNESS OF NANO-FILLED COMPOSITES: A LITERATURE REVIEW

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ABSTRACT

This research seeks to ascertain the impact of hydrogen peroxide bleaching gel on the color stability and roughness of nano-filled composite restoration. The most important aesthetic elements of restoration are surface gloss, surface roughness, and color. It has been claimed that saliva, food ingredients, and beverages may compromise the integrity and aesthetics of dental composites, causing them to degrade in the mouth. For aesthetic restorations including anterior and posterior teeth, resin composites have taken the place of porcelain as the preferred material. Resin composites are now the preferred material for aesthetic restorations including both anterior and posterior teeth due to their better physical and adhesive qualities. Composites now play a significant part in contemporary restorative dentistry due to the rising desire for aesthetically pleasing restorations in recent years. Composite restorations are viewed as the major alternative for repairing front teeth as a result of the phase-down of dental amalgam, and its use in posterior restorations is expanding rapidly.

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Introduction

Surface roughness, surface gloss, and color are the aesthetic components of restoration that are most crucial [1]. Saliva, food

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ingredients, and drinks have been said to have an impact on the quality and appearance of dental composites, which can cause them to degrade in the oral environment. The nanofiller particles in composites, which can be either discrete particles or agglomerated nanoclusters with filler particles smaller than 100 nm, are responsible for the high polishability and gloss. Nanohybrid composites often include bigger filler particles (0.6–1 m) and prepolymerized fillers. These alterations can modify the interaction of nanofiller or nanohybrid composites with in-office and take-home bleaching agents. Bleaching agents had no significant impact (P = 0.1412) on staining solutions (P = 0.2201) or on the interplay of these variables (P = 0.9930) on the roughness of the specimens. We discovered statistically significant variations in color, with the 35% hydrogen peroxide agent producing the most noticeable shift. After bleaching treatments, the surface roughness increased, and the color became lighter, demonstrating that 35% hydrogen peroxide was the most efficient bleaching agent. There was a statistically significant difference in the median roughness, according to an analysis of the surface roughness. Bleaching by itself does not result in clinically unfavorable color or smoothness alterations. Both of the tested composites' color and smoothness were impacted by bleaching and surface treatments as they wore down. The nanofiller resin composite also has the potential to become stained over time.

Nanofiller Composites

Composites now play a significant part in contemporary restorative dentistry due to the rising desire for aesthetically pleasing restorations in recent years. Composite restorations are viewed as the major alternative for repairing front teeth as a result of the phase-down of dental amalgam, and its use in posterior restorations is expanding rapidly. Since these materials were first used in dentistry, composites have advanced tremendously in technology. The improvement of the monomer, filler, and initiator system has primarily been responsible for the most critical developments in commercial composites during the last several decades. The kind of fillers affects the material's radiopacity and mechanical characteristics as well as improves handling qualities, particularly consistency, polishability, and gloss stability. Typically, filler characteristics like kind, distribution, and average particle size have been used to categorize composites [2].

To increase initial polishability and gloss retention, filler particle sizes have constantly shrunk from hybrid, micro-hybrid, and micro-filled composites to nano-sized composites. Nano-filled and nanohybrid composites are the two primary nano-sized composite materials available today. While nanofiller composites solely use nanometer-sized fillers, the majority of which are clustered into larger secondary particles, nanohybrid composites use both nanometer- and micrometer-sized fillers [3].

Although the nanofiller and nanohybrid composites are state-of-the-art in terms of filler formulation, a recent systematic review of in vitro studies revealed that there is no evidence to support that these properties of nano-sized composites have improved after in vitro simulation, including better surface smoothness and polishing retention. Results from clinical research comparing hybrid composites to nanofiller and nanohybrid composites in posterior restorations have generated debate [4]. Recent research [2] compares nanofiller/nanohybrid composites to hybrid composites. However, because of the study's limited search technique, it could not do a meta-analysis, making it difficult to assess the extent of the impact [5].

Materials and Methods

A systematic literature review from 2010 to 2022 was performed using PubMed, Medline, and ScienceDirect databases. The keywords used were “hydrogen perhydroxide,” “color” “and “nano-filled” **(Table 1)**. In addition, the PRISMA flowchart was used to describe the selection process of searched articles.

Table 1. Inclusion and exclusion criteria

№	Inclusion criteria	Exclusion criteria
1.	Case-control, randomized control studies, systematic reviews.	Expert opinions, or narrative reviews
2.	Published between 2010 and 2022	Out of the specified time range
3.	Studies including nano-filled composites	Studies including other types of composites
4.	English language of publication	Language other than English
7.	In vivo (humans)	In vitro

Results and Discussion

The most important aesthetic factors in a restoration are color, surface gloss, and surface roughness. According to reports, saliva, food ingredients, and beverages may have an impact on the integrity and aesthetics of dental composites, causing them to degrade in the oral environment. As the preferred material for cosmetic restorations including anterior and posterior teeth, resin composites have taken the place of porcelain. The maintenance of color stability in resin composites may be affected by a variety of inherent and external factors. Changes to the matrix or filler components of resin composites and insufficient polymerization are two fundamental causes that may result in discolouration. Examples of extrinsic impacts include adsorption and absorption of stains from exposure to specific beverages, tobacco products, and other food color additives [6].

Newer composite materials with different material structures have been developed as a result of ongoing material science research and development [7, 8].

Resin composites are now the preferred material for aesthetic restorations including both anterior and posterior teeth due to their better physical and adhesive qualities. Surface roughness, surface gloss, and color are the aesthetic components of restoration that are most crucial [1]. Saliva, food ingredients, and drinks have been said to have an impact on the quality and appearance of dental composites, which can cause them to degrade in the oral environment. The color stability of resin composites is affected by a number of internal and external factors. Intrinsic factors that cause discoloration include matrix or filler component changes and inadequate polymerization. Extrinsic variables may include stain adsorption and absorption from different drinks, cigarettes, and other food color additives [9].

Newer composite materials with different material structures have been developed as a result of ongoing material science research and development [10, 11].

Because they are so accessible and patients have more aesthetic needs, at-home bleaching methods are becoming more popular. The effect that these agents have on the physical and optical characteristics of the various restorative materials must be evaluated as they interact with one another. There aren't many studies examining how bleaching treatments affect how long newer resin composites retain their color after being soiled with widely found food items in Indian households [12].

Effect of Hydrogen Peroxide

The self-esteem and quality of life of a person are significantly impacted by the widely used aesthetic method of tooth whitening. The amount of hydrogen peroxide or carbamide peroxide used varies depending on whether the operation is done in-office or at home. At the core of the whitening process is the release of reactive oxygen molecules (O2•−), hydrogen peroxide anions, hydroperoxyl (HO2•−), and hydroxyl (HO•). Strong oxidizers, these ions can break down long-chain chromophores into shorter-chain, colorless compounds.

More conclusive data regarding surface modifications in resin-based composites is required. For micro-filled and hybrid composites, increased roughness was only associated with 10–16% carbamide peroxide. Hybrid and nanohybrid composites have been demonstrated to lose gloss when exposed to carbamide and hydrogen peroxide [13, 14]. It was anticipated that oxidizing chemicals would increase the surface porosity of the polymer matrix or the filler debonding due to increased water absorption, changing the surface's roughness and gloss. A more recent analysis supported the conflicting findings on the effect of whitening agents on surface topography, with an equivalent percentage of trials showing either no effect or significant changes in surface topography. Variations in surface reflectance were associated with hydrogen peroxide (30–35%). Following treatment with whitening toothpaste, it was shown that surface roughness of hybrid and nanocomposites increased; this was most likely caused by the abrasive effect of toothpaste rather than whitening chemicals [15].

Surface Roughness and Color Stability

The kind of matrix, the kind of filler, and the coloring agents all affect how colored a resin composite becomes. The organic matrix is further harmed when the substance is exposed to dyes, alcoholic beverages, and acidic foods that are frequently included in diets. Another important aspect that affects composite discolouration is roughness. The durability and aesthetics of resin composites are enhanced by fine finishing and polishing [16].

In the course of treatments, resin composite restorations and teeth are both bleached. As a result of probable physical and mechanical changes in their smoothness, hardness, and color stability after treatment, these restorations are regularly updated. According to Rodrigues and others13, bleaching treatments cause a resin composite surface to become more porous and abrasive, which may make discolouration easier. However, in some circumstances, such as when the dental tissue and restorative material interface in bleached teeth are unaffected and the bleached enamel color matches the restoration color, resin composite restorations can be kept in place after bleaching [17].

The surface texture of polished and bleached specimens remained unchanged when Kwon and colleagues [18] evaluated the effects of 15% carbamide peroxide and 38% hydrogen peroxide on three different resin composites. Carey [19] found statistically significant variations in the color stability of samples bleached with 35% hydrogen peroxide. Yu and colleagues [20] looked into how bleaching agents affected the surfaces of various materials. They suggested that polishing the restorations during the process that came into contact with the bleaching gel may be crucial.

Surface Roughness Test (Ra)

ANOVA of Experiment 1 demonstrated differences in roughness average in specimens treated with various bleaching agents (P< 0.05), and the Tukey test showed that the group bleached with 35% hydrogen peroxide had a considerably greater roughness mean (Ra) than the group with 10% carbamide peroxide. The experiment's analysis of variance showed that the surface roughness was different at the beginning and the end, with the roughness at the beginning being considerably lower than the roughness at the end (P 0.01). However, the roughness of the samples was not affected significantly by the bleaching chemicals (P= 0.1412), staining solutions (P = 0.2201), or the combination of these variables (P = 0.9930). Statistically, significant color changes were detected between the three bleaching agents (P = 0.05) in the parameters E1, a1, and b1 (Experiment 1), and the most significant values of E1, a1, and b1 were achieved [21]. The hydrogen peroxide 35% exhibited the most effective color change. Analysis of variance means and 95% confidence intervals (standard deviations and upper and lower bounds). E2 compared colors before and after staining using each specific staining solution. After being immersed in coffee and wine, the brightness was found to diminish, and the values of a* rose, with red pigmentation dominating and a yellower tone in b*. Regardless of the bleaching agent, red wine induced the most remarkable E2 color shift. The lower E2 values were reported following immersion in distilled water. The results of the bleaching procedures on Filtek Supreme were visible, with an increase in surface roughness and a lighter hue indicating that 35% hydrogen peroxide was the most efficient bleaching agent. Compared to pre- and post-bleaching measurements, surface roughness increased following the staining of the nanofiller resin composite. The Colour altered to a deeper tone after staining, compared to baseline. The water-immersed samples were the lightest in color, while the wine-immersed samples were the most heavily stained [22].

Effect on Surface Roughness

There was a statistically significant variation in the average roughness of the surfaces analyzed. Among the two bleaching chemicals tested in this research, the one with the lowest pH (35% concentration) and greatest concentration (95%) of the active agent), hydrogen peroxide, was shown to increase surface roughness more than the other (carbamide peroxide, 10%). There was a statistically insignificant difference between the coffee, wine, and distilled water, although immersion in all studied liquids significantly influenced the specimens by increasing their surface roughness. Resin composition, staining material, and staining period are all responsible for the maximum surface roughness in stained resin composites. The VITA Easyshade spectrophotometer was used to determine the exact color [23, 24]. The CIELAB color space parameter (E1) shows statistically significant variations among bleaching agents; the 35% hydrogen peroxide gel (lighter color) caused the most significant change in shade, followed by the 16% and 10% carbamide peroxide solutions. Similar findings have been reported in previous studies suggesting that the 35% bleaching gel's higher value of E1 may be related to its more significant amount of hydrogen and more acidic pH than the other homeuse gels evaluated in this research [25].

Although the obtained value (E1 3.3) might be clinically apparent in a subjective visual evaluation, the color shade change is likely due to the attack of the bleaching gel on the matrix crosslinking, particle charge, and interface. This mechanism is influenced by the degree of conversion, resin formulation, and bleaching treatment. Most common household bleaching chemicals have a pH close to 7.0, which may explain why lower quantities of carbamide peroxide exhibited less tendency to alter the resin's Colour. For all three test substrates, bleaching gel significantly enhanced surface roughness in comparison to whitening strips (p 0.0001) [26]. In comparison to enamel ($p = 0.023$) and HU ($p = 0.042$), the surface roughness of TS was observed to be substantially higher both before and after treatment with the bleaching gel and whitening strips. It was found that neither the whitening strips nor the bleaching gel appreciably changed the enamel's or HU's surface roughness [6].

Effect on Colour Change

When comparing bleaching gel to whitening strips, the Colour was altered more (ECycling, p 0.0001) in the former treatment for all three substrates (enamel, HU, and TS). Only the enamel whitened with strips was noticeably different in Colour from the untreated enamel ($E > 3.3$) after exposure to the bleaching gel. In a three-way color change comparison (enamel, HU, and TS), enamel had the most significant change (p 0.0001), followed by HU and TS. While both composites had some degree of hue shift, there were no discernible variations between them. The enamel and the resin composites (nano- and micro-hybrids) had a clinically unacceptable color difference when 15% CP bleaching gel and 10% HP whitening strips were applied in a cyclic pattern [27].

To lessen the negative effects on surface roughness and hardness, doctors should advise patients to refrain from consuming colorful beverages or meals during bleaching and to promptly apply remineralizing treatments, such as topical fluoride, following bleaching. Composites containing nanofiller particles provide excellent polishability and gloss because the filler particles are so small (below 100 nm) and are either in the form of single particles or agglomerated nanoclusters. Nanohybrid composites use bigger filler particles (0.6-1 m) and prepolymerized fillers). Nano-filled, nanohybrid composites may respond differently to in-office and at-home bleaching treatments due to above mentioned and other potential modifications [28].

While the effects of whitening chemicals on natural and artificial teeth are known, the same cannot be said for resin-based composites. The majority of studies demonstrate that the differences in color perception between discolored and discolored composites are greater than the CIEDE2000 50:50% perceptibility (E00=0.81) but less than the 50:50% acceptability thresholds (E00=1.77), with the 50:50% acceptability threshold being exceeded only in a small number of studies. Patients should be informed that whitening procedures for composite resin only have a limited effect and that composite restorations do not alter color in a way that is comparable to teeth. The clinical significance of this idea is that composite restorations will often need to be replaced after bleaching treatments. Using either at-home or professional techniques, it has been claimed that composites stained by wine, tea, or coffee may be effectively whitened using carbamide or hydrogen peroxide agents. Depending on the material, the whitening agent, or the hue, the whitening effects were observed to vary [29].

Conclusion

After bleaching treatments, the surface roughness increased, and the color became lighter, demonstrating that 35% hydrogen peroxide was the most efficient bleaching agent. There was a statistically significant difference in the median roughness, according to an analysis of the surface roughness. Bleaching by itself does not result in clinically unfavorable color or smoothness alterations. Both of the tested composites' color and smoothness were impacted by bleaching and surface treatments as they wore down. The nanofiller resin composite also has the potential to become stained over time.

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