Review Article

INFLUENCE OF HYDROGEN PEROXIDE ON THE COLOR, OPACITY, AND FLUORESCENCE OF COMPOSITE RESINS: A SYSTEMATIC REVIEW

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ABSTRACT

The clinical effectiveness of restorative materials depends on their ability to mimic the color and transparency of natural teeth. Accordingly, it is vital to understand the influence of bleaching chemicals on the color and translucency of resin composites. Bleaching chemicals may be administered to the teeth in a dental clinic under expert supervision or at home by patients. A systematic literature review from 2010 to 2022 was performed using PubMed, Medline, and ScienceDirect databases. The keywords used were "hydrogen peroxide," "composite resins," and "bleaching." In addition, the PRISMA flowchart was used to describe the selection process of searched articles. The Cochrane risk of bias assessment method was used to assess the quality of the studies. A total of nine studies were included in this review, with six of them stating no significant change in the color, opacity, and fluorescence of composite restorations. The majority of the studies revealed no significant change in the color or fluorescence of composite restorations after being exposed to different concentrations of hydrogen peroxide. Therefore hydrogen peroxide can be safely used among patients with composite restorations.

Key words: Hydrogen peroxide, Composite resins, Bleaching, Systematic review.

Introduction

Tooth whitening is gaining acceptance and recognition because it creates an excellent aesthetic impression. It may be used to cure discolored teeth at a cheap cost and without causing harm to the enamel and dentine. Bleaching compounds efficiently whiten teeth, although the consequences of this procedure on composite resin materials are debatable [1-3]. Office-type whitening is a therapy procedure done by clinicians to erase the discoloration of teeth caused by internal and external sources. In professional treatment methods, high concentrations of hydrogen peroxide (30-35%) are administered to the surface of the teeth and left for 20 or 30 minutes. This technique comprises four treatments set at 2-4 weeks intervals, based on the product's instructions, and is entirely under the clinician's discretion. The most widely used bleaching agent is hydrogen peroxide (HP) [4]. 1 In-office bleaching chemicals have high HP concentrations (usually 15 percent to 38 percent). In contrast, at-home bleaching solutions have HP percentages ranging from 3% to 10%. Most office bleaching and domestic bleaching techniques have been proven to be effective. However, it has been stated that outcomes may vary based on variables such as the kind of stain, the patient's age, the quantity of the bleaching agent, and the length and recurrence of treatment [5, 6].

Patients and dentists alike are understandably concerned about the accuracy of resin composite restorative material color matches. There is a considerable range of variance in the color and transparency of natural teeth across patients and between individual teeth. The clinical effectiveness of restorative materials depends on their ability to mimic the color and transparency of natural teeth. Accordingly, it is vital to understand the influence of bleaching chemicals on the color and translucency of resin composites [7, 8]. Bleaching chemicals may be administered to the teeth in a dental clinic under expert supervision or at home by patients. Oxygenating chemicals, often containing up to 15% HP4 active component, are applied to the teeth during the home bleaching operation using custom-made or store-bought guards [9, 10].

In a home bleaching process, the teeth and any restorations already in place are exposed to bleaching solutions for many hours. Applying a bleaching chemical at home might change the color of the current restorative material since peroxides break down into stable free radicals, which then break down into big colored molecules. The oxidation of surface pigments and amine compounds is blamed for the color shifts in the restoration materials. Color changes may occur in various restorative materials depending on the quantity of resin matrix used and the degree of matrix conversion to the polymer. Resin composite materials, in particular, are particularly susceptible to chemical modification generated by the acidic component of bleaching chemicals due to their organic matrix [11, 12].

Materials and Methods

Aims of the study

This research aimed to evaluate the influence of hydrogen peroxide on the color, opacity, and fluorescence of composite resins

A systematic literature review from 2010 to 2022 was performed using PubMed, Medline, and ScienceDirect databases. The keywords used were "hydrogen peroxide," "composite resins," and "bleaching" **(Table 1)**. In addition, the PRISMA flowchart was used to describe the selection process of searched articles **(Figure 1)**.

Table 1. Inclusion and exclusion criteria

№	Inclusion criteria	Exclusion criteria
1.	Case-control and randomized control studies	Systematic reviews or meta-analyses or expert opinions, or narrative reviews
2.	Published between 2010 and 2022	Out of the specified time range
4.	English language of publication	Language other than English
7.	In vivo (humans)	In vitro

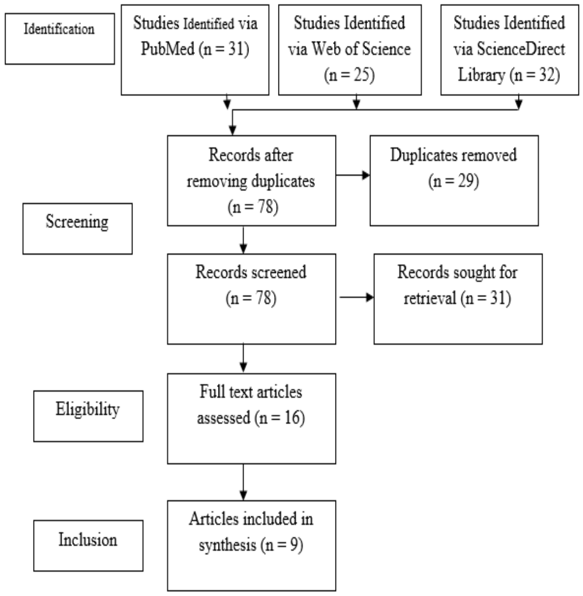

Figure 1. PRISMA Flow Diagram

Risk of bias assessment

Cochrane risk of bias assessment method was used to assess the studies' quality **(Table 2)**.

Table 2. Summary of Cochrane Risk of Bias Assessment

Study	Selection Bias/Appropriate control selection/baseline characteristics similarity	Selection bias in randomization	Selection bias in allocation concealment	Performance-related bias in blinding	Reporting bias/Selective reporting of outcomes	Detection bias Blinding outcome assessors	Accounting for confounding bias
Torres *et al.*, (2012)	+	+	-	+	+	+	-
Pecho *et al.* (2019)	+	+	+	+	+	+	-
Gurbuz *et al.*, (2013)	+	+	+	+	+	_	+
Wang *et al.*, (2011)	+	+	+	+	+	+	-
Karakaya *et al.*, (2017)	+	-	+	+	+	-	+
Hussain *et al.*, (2021)	+	+	+	-	+	+	+
Mehrgan *et al.*, (2021)	+	+	-	+	+	+	+
Kamangar *et al.*, (2014)	+	+	+	+	+	+	-
Kazemi *et al.*, (2016)	+	+	-	+	+	+	+

Results and Discussion

Table 3. Summary of the studies included in the systematic review.

Author's name	Specimens	Objective	Disc thickness	Time period	Outcome
Torres *et al*., (2012) [13]	210	The purpose of this study was to see how 20% and 35% hydrogen peroxide bleaching gels affected the color, opacity, and fluorescence of composite resins	3 mm in diameter and 2 mm thick	10 days	For all studied factors, no change in opacity was found. Fluorescence changes were affected by the composite resin brand and the bleaching agent.
Pecho *et al*., (2019) [14]	10	The purpose of this study was to see how a 35% hydrogen peroxide gel affected the color and whiteness changes of resin-based composites (RBC)		7 days	There were no significant differences in color differences (E* ab and E00) across all composite materials tested for all periods (T1-T0 and T2-T0; P >.05).
Gurbuz *et al*., (2013) [15]	20	The purpose of this research was to see how an at-home peroxide whitening agent applied through a whitening strip affected the color and surface roughness of a nano-filled composite resin and an ormocer-based resin	2 mm thick, 10 mm diameter	21	the surface roughness of the resin composites before and after whitening was not different (p > 0.05).
Wang *et al*., (2011) [16]	6	The purpose of this research was to look at the surface texture of composite restorations following various bleaching techniques	6 mm diameter X 3 mm thickness	28 days	Surface roughness variations in resin composites following bleaching are substance and period-dependent. Bleaching gels had an impact on nano-filled and microhybrid composite resins. Bleaching had the least effect on enamel.
Karakaya *et al*., (2017) [17]	60	The purpose of this research was to assess the color stability of three restorative materials, the capacity of various solutions to discolor, the efficiency of two office bleaching chemicals, and surface roughness and topography		14 days	there was a statistically significant difference in E00 values of restorative materials, with LU exhibiting the most and CME exhibiting the least color changes (p0,05).
Hussain *et al*., (2021) [18]	60	The purpose of this research was to determine the effects of widely consumed beverages and bleaching on the color of composite repair	1 mm and a diameter of 10 mm.	45 minutes	The bleaching agent's recovery action could not restore the composite's original color before staining.
Mehrgan *et al*., (2021) [19]	45	The purpose of this research was to investigate the effects of charcoal, hydrogen peroxide, and abrasive whitening toothpaste on the color stability of a resin composite	2 mm in diameter and 7 mm in height	30 days	Both Δa and ΔE values (P value = 0.19 and P value = 0.28, respectively) did not significantly differ amongst the five experimental groups, as determined by ANOVA. When comparing the groups, significant differences were seen in L and b values (P = 0.004 and P = 0.05, respectively).

Kamangar *et al*., (2014) [20]	54	The purpose of this research was to compare the effects of 40% hydrogen peroxide on the microhardness and color change of restorative materials	2 mm thickness and 10 mm diameter	14 days	Bleaching considerably reduced the microhardness of Z250 and Z350, but there was no difference in the P90 test and control subgroups.
Kazemi *et al*.,(2016) [21]	36	This research aimed to evaluate and compare color changes in a range of composite materials following bleaching treatments.	3 mm 8 mm	14 days	The findings revealed that bleaching aged composites with HP had a 40% influence on their color because the treated composites were more susceptible to color change than the control group samples, which was significant (P 0.05).

The current investigation by Torres *et al*. (2012) [13] compared the lightening results of hydrogen peroxide bleaching gels with 20% and 35% concentrations on composite resins' color, opacity, and fluorescence. Seven different brands of composite resin were evaluated by creating 210 test specimens (3 mm in diameter and 2 mm thick) from each material. Two-way analysis of variance and Tukey tests (p0.05) were used to analyze the data following the completion of the final assessments. The greatest bleaching effect was seen with 35% hydrogen peroxide gel, but all treatments produced statistically significant (p0.0001) improvements in skin tone. All measured parameters showed no discernible opacity variation. Composite resin brand (p0.0001) and bleaching therapy (p=0.0016) were significant predictors of fluorescence changes, respectively. There were no statistically significant differences in fluorescence between the various bleaching gel concentrations, as measured by the Tukey test.

The study by Pecho *et al*. (2019) [14] determined how hydrogen peroxide gel at 35% affected the color and whiteness of resin-based composites (RBC). All RBC samples were measured against a black background using a dental spectrophotometer to determine their CIELAB color coordinates. Ten samples of enamel in shade A3.5 were made by dividing a mold made of stainless steel. Each specimen underwent two rounds of simulated bleaching, separated by one week. A two-way analysis of variance was used to compare and contrast the means and standard deviations of L*, a*, b*, and WID (two-way ANOVA). The results display the average and standard deviation of color differences (E* ab and E00) for each RBC at the start of the bleaching process (T0), halfway through (T1), and at the end of the bleaching process (T2). There were no statistically significant differences between any of the composites tested across any of the periods (T1-T0, T2-T0, P >.05) about the color differences (E* ab and E00). For all RBCs, the average difference in E* ab between T2 and T0 was greater than the 50%:50% PT value. Mean values of E00 over all periods were below the 50%:50% PT threshold, regardless of the RBC.

This research by Gurbuz *et al*. (2013) [15] compared the color and surface roughness of a nano-filler composite resin and an ormocer-based resin after being treated with a peroxide whitening solution at home using a whitening strip. Whiteners are oxygenating chemicals like carbamide peroxide or hydrogen peroxide. Disc-shaped specimens made of nanofiller resin composite (n = 10) and ormocer (n = 10) were created. When fabricating the specimens (2 mm thick, 10 mm diameter). The whitening treatments lasted for 21 days. After bleaching, L values rose for both groups (p 0.05). All groups' values went higher following the whitening process, but the differences weren't statistically significant. After whitening, the b value rose considerably (p 0.05) for the nanofiller composite group but declined significantly (p 0.05) for the ormocer group. Duncan's test showed that the E values for the two restoration materials were not significantly different (p > 0.05). **Table 3** shows the average roughness of the studied restoration materials before and after bleaching. When put through the Duncan test, the whitening process did not affect the surface roughness of the two resin-based restorative products. Also, when used as restoratives, there was no difference in surface roughness between the two materials before and after whitening (p > 0.05).

This analysis by Wang *et al*. (2011) [16] proposed to compare the effects of various bleaching techniques on the surface roughness of composite restorations. Daily bleaching for four weeks was required when using WS for at-home bleaching. Six resin samples (6 mm in diameter and 3 mm in thickness) were collected to test the efficacy of each bleaching method. At a 5% significance level, we ran two-way ANOVA and Bonferroni tests on the collected data to see how each bleaching method performed. WHP treatment gradually reshaped the Filtek Supreme composite in noticeable ways. Grandio's surface roughness changed significantly during the evaluation period when WMAXX was applied compared to the other nanocomposites. In contrast to the nanofiller materials, Filtek Z250 with WS showed noticeable surface changes over time. Bleaching resin composites cause surface roughness variations that vary depending on the composite material and the length of time since bleaching began. The bleaching gels degraded

Microhybrid and nanofiller composite resins. The effects of bleaching were minimal on enamel.

The researchers Karakaya *et al*. (2017) [17] wanted to see how well two commercial bleaching chemicals performed in the office, how well the agents removed stains, how rough the surface was after bleaching, and how stable the color after the bleaching procedure was in three different restorative materials. Clearfil Majesty Esthetic (CME), Lava Ultimate (LU), and Vita Enamic (VE) each had sixty samples made. The surface roughness and topography of three randomly selected samples from each group were examined using an atomic force microscope. They spent two weeks submerged in three different staining solutions before being bleached. Only the DW groups of CME and VE exhibited no discernible color changes (E00 0,8) after staining. The TC, RW LU, and VE groups showed clinically inappropriate color alterations (E00 > 1,8). The E00 values of TC groups of LU and VE did not vary statistically from one another (p>0,05). However, they differed significantly from the values of RW groups of LU and VE (p0,05). There was a statistically significant difference (p0,05) in the E00 values of restorative materials, with LU exhibiting the most significant color changes and CME exhibiting the lowest.

Hussain *et al*. (2021) [18] determined how bleaching and popular beverages affected the shade of composite repair. An 8-millimeter-wide and 1.5-millimeter-thick plastic mold was used to create the discs. Each resin composite was used to create fifteen discs, and standard color measurements were taken from them. A spectrophotometer was used for color analysis. Sixty disc-shaped specimens were made from a 1 mm thick, 10 mm in diameter Teflon mold, then filled with A2-colored composite resin. A two-way analysis of variance (p 0.001) revealed that E1 was significantly affected by the storage solution and brand of restorative material for their discoloration. After bleaching, samples kept in coffee or tea exhibited color changes larger than 3.3. In contrast, those kept in distilled water showed color changes of less than 3.3 for both resin composite restorative material brands. Although we observed substantial color enhancements in the specimens post-bleaching, we discovered that when comparing the post-bleaching color to the baseline color, all groups had (E3) values above 3.3. The bleaching agent's recovery impact was insufficient to restore the composite's pre-stain hue.

The research conducted by Mehrgan *et al*. (2021) [19] evaluated the impact of three teeth-whitening toothpaste on the color stability of a resin composite: those containing charcoal, hydrogen peroxide, and abrasives. For this experiment, 45 disc-shaped composite samples were made by compressing the composite in a stainless steel mold (2 mm in diameter and 7 mm in height). A spectrophotometer reading was taken at the end of the 30 days to determine the true hue. One-way analysis of variance and Tukey's post hoc test were used to examine the data. Neither a nor the E values were significantly different across the experimental groups. However, the groups noticed a noticeable variation in L and b values. The GT and GC groups shifted toward red, whereas the other groups shifted toward green. Regarding Δb, all groups exhibited a blue color shift except the GT group, which showed yellow.

Kamangar *et al*. (2014) [20] evaluated the microhardness and color change of a silorane-based composite resin compared to two methacrylate-based composites exposed to 40% hydrogen peroxide. Filtek P90 (P90), Filtek Z350XT Enamel (Z350), and Filtek Z250 (Z250) (3MESPE) (n=18) were all used to create 54 disc-shaped specimens (A3 shade, 2 mm thickness, and 10 mm). Once a day, for four hours, for two weeks, Opalescence PF was administered. Compared to Z250 and Z350, P90 had a considerably reduced microhardness at rest (P0.001), whereas there was no difference between the two composites (P=0.293). Both Z250 and Z350 microhardness reduced considerably after bleaching treatments (P 0.001), but P90 microhardness did not vary between the test and control groups (P> 0.05). The two forms of bleaching were not differentiated at the 0.05 level of significance. The E values after OB bleaching were 3.12(1.97) for P90, 3.31(1.84) for Z250, and 3.7(2.11) for Z350. After OP bleaching, these numbers remained unchanged at 5.98(2.42), 4.66(2.85), and 4.90(2.78).

Kazemi *et al*. (2016) [21] examined and evaluated the color changes that resulted from bleaching treatments on several composite materials. This investigation applied hydrogen peroxide 40% to composite samples of four distinct kinds. For each composite (Z100, Z250, Z350, and P90), 36 discs measuring 3 mm by 8 mm were made. Secondary colors and color shifts were detected after 14 days of treatment. Analysis of variance and Tukey were used to examine the data, and a significance level of P = 0.05 was determined. Since the treated composites were more susceptible to color change than the control group samples, it was determined that bleaching aged composites with 40% hydrogen peroxide affected their color.

Recent studies have demonstrated that bleaching processes may influence the final color of composite resins (E values). Compared to the 20% hydrogen peroxide bleaching group and the control group, the 35% hydrogen peroxide bleaching treatment group showed significantly higher color variation using the multiple comparisons test [22]. The 20% hydrogen peroxide group was not different from the control group. The current investigation demonstrates that the concentration of hydrogen peroxide gels also impacts the degree of color change.

The current investigation did not demonstrate significant color variations (ΔE^*ab and $\Delta E00$) following the first (T1-T0) and second (T2-T0) bleaching treatments for all RBCs (P > .05). However, there was a difference between both measurements when the findings were examined using visual thresholds. Using E* ab resulted in readings above PT after the second bleaching treatment, whereas using E00 resulted in readings below PT after both applications. According to previous research, the overall bleaching period is essentially more than the bleaching chemical concentration [23]. Another research found no variation in E* ab values for three bleaching products (6.5% hydrogen peroxide strip and 14% hydrogen peroxide strip) applied to hybrid and nanohybrid resin composites over one week vs. two weeks [24].

It should also be mentioned that the materials employed in this investigation varied in structure but experienced the same impact of the whitening chemical in terms of overall color change and surface roughness. Studies examining hydrogen peroxide's effectiveness as a bleaching agent have reached conflicting results. When Yap *et al*. applied 35% H2O2 to nanofiller composites, they found a significant rise in surface roughness [25]. According to previous scholarly works, hydrogen peroxide gel has been demonstrated to alter surface roughness. This roughening presumably happens to owe to assault of the organic matrix, creating a weakening of the substance and resulting from glossing loss.

The AFM investigation revealed that all specimens exhibited topographical abnormalities. Compared to the control groups, CAD/CAM blocks, composite resin surface topography, and Ra values differed. While the surface modifications were more homogeneous at composite resins, CAD/CAM blocks had greater spaces for overhangs and recessions. Restoration materials may exhibit elevated surface roughness as a result of the action of high-energy free radicals produced from peroxides at the resin-filler interface, which may result in either total or partial filler-matrix deboning and water absorption [26, 27].

This research showed that the two composite kinds tested here had different degrees of color stability. The discoloring potential of a resin composite is determined by the matrix resin's hydrophilicity and the composite's water absorption rate [28]. The quantity of water sorption a resin composite has may be affected by the resin content and the connection between the filler and the resin. However, the discoloration of the composite might be due to a significant number of unreacted monomers. Increased solubility and poor color stability are effects of these unreacted monomers, which suggest a low degree of conversion [29].

Brushing with Colgate Optic White toothpaste significantly reduced the discoloration caused by wine in a study conducted by Demir *et al*. [30]. The researchers found that other whitening kinds of toothpaste mechanisms of action did not affect the color stability of a resin composite after immersion in red wine. Our results revealed that Colgate Optic White reduced the value of E to a clinically acceptable level (E=2.9).

The current investigation suggests that the decrease in microhardness seen in this composite may be attributed to the process mentioned above as well as the influence of the bleaching agent on the filler-matrix interface. P90 composite is insoluble because of the siloxane used in its chemical composition, which also increases its hydrophobicity [31]. This is presumably the cause for no substantial loss in the microhardness of this composite following bleaching in the current investigation.

Although there was no statistically significant difference in E between the HP40% and CP16% groups, both of these groups nevertheless had E values that were considerably greater than the control group. The bleaching impact was seen in all combinations. Changing the color of Z250 was much greater than in other groups, but no significant difference was seen among other composites. According to Mendes *et al*. [32], bleaching Z350 composite with 10% hydrogen peroxide resulted in color alterations that were not physiologically acceptable. The clinically meaningful difference between the two groups was calculated to be 3.7 by Mendes *et al*.

Conclusion

Majority of the studies revealed no significant change in the color or fluorescence of composite restorations after being exposed to different concentrations of hydrogen peroxide. Therefore hydrogen peroxide can be safely used among patients with composite restorations.

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