Journal of Dentomaxillofacial Radiology, Pathology and Surgery

Winter 2025, Volume 14, Number 1

Review article: Factors Influencing Color Changes in Composite Resin Restorations after Bleaching: A Narrative Review

Mahsa Koochaki[1], Parisa Rahimirad[2], Mohammadamin Shakerinia[2], Hoorieh Alsadat Hoseini Basti[3], Yasaman Sadeghi[4], Mona Shameli[2*]

1. Department of Oral and Maxillofacial Medicine, School of Dentistry, Guilan University of Medical Sciences, Rasht, Iran
2. Student Research Committee, School of Dentistry, Guilan University of Medical Sciences, Rasht, Iran
3. Dental Sciences Research Center, Department of Restorative, School of Dentistry, Guilan University of Medical Sciences, Rasht, Iran
4. Department of Restorative, School of Dentistry, Guilan University of Medical Sciences, Rasht

Use your device to scan and read the article online

Citation Koochaki M, Rahimirad P, Shakerinia M, Alsadat Hoseini Basti H, Sadeghi Y, Shameli M. Factors Influencing Color Changes in Composite Resin Restorations after Bleaching: A Narrative Review. Journal of Dentomaxillofacial Radiology, Pathology and Surgery. 2025; 14(1): 21-28

http://dx.doi.org/10.32592/3dj.14.1.21

ABSTRACT

Article info:
Received: 12 Jan 2025
Accepted: 14 Feb 2025
Available Online: 01 Mar 2025

Keywords:
*Composite Resins
*Tooth Discoloration
*Tooth Bleaching

With the growing demand for aesthetic dental treatments, tooth bleaching has emerged as a widely used, non-invasive procedure aimed at enhancing dental appearance and minimizing discoloration. However, bleaching agents may affect the color stability of composite resin restorations. This narrative literature review aims to evaluate the effects of various bleaching protocols on composite resin restorations and compare these effects with changes observed in natural teeth. A comprehensive literature search was conducted through PubMed (MEDLINE), Scopus, and Web of Science up to May 2025, using relevant keywords. Additional sources were identified via a Google-based manual search. A total of 146 articles were included based on their relevance to at-home and in-office bleaching techniques and bleaching agent concentrations. Findings indicate that materials such as silorane-based and Ormocer-based nanohybrid composites are more susceptible to discoloration when exposed to high concentrations of hydrogen peroxide (up to 40%) during in-office bleaching. Due to the considerable variability in reported outcomes across existing studies, there is a need for further standardized and rigorously designed investigations to better understand the mechanisms of color change in resin-based restorations and to guide clinical decision-making.

1. Introduction

In recent years, there has been a notable increase in the demand for aesthetic dental treatments as individuals increasingly seek to achieve an ideal smile (1). Advances in dental materials and technologies have made aesthetic procedures—such as composite resin restorations and tooth bleaching—more widely accessible and frequently performed (2).

Composite resin restorations, known for their tooth-colored appearance and versatility, have become a preferred option in restorative dentistry (3). However, tooth discoloration continues to be a significant aesthetic concern for patients and remains one of the primary reasons for seeking dental care (4). To address this issue and enhance the natural appearance of teeth, bleaching procedures have become a common clinical approach. These techniques are generally categorized into two main types: in-office bleaching (also known as power bleaching) and at-home bleaching (also referred to as night-guard vital bleaching) (5,6).

Both in-office and at-home bleaching methods have been shown to be effective (7). These agents work by decomposing into unstable free radicals that lead to whitening of the tooth structure. The free radicals then further decompose into larger pigmented molecules through an oxidation or reduction reaction. Consequently, this chemical reaction modifies the molecular structure of organic substances within the tooth, resulting in a change in color (8).

There is growing evidence that composite resin materials are particularly susceptible to chemical changes as a result of their organic matrix, in contrast to inert metal or ceramic restorations (9). In general, bleaching agents yield changes in both natural teeth and preexisting composite resin restorations. The alterations in color of

*** Corresponding Authors:**
Mona Shameli
***Address:** Student Research Committee, School of Dentistry, Guilan University of Medical Sciences, Rasht, Iran*
***Tel:** +981333486423*
***E-mail:** monashameli@gmail.com*

the restorative materials depend on factors such as the type and concentration of bleaching agent used, as well as the duration of the bleaching procedures (10). More precisely, the amount of resin matrix and the degree of conversion of the resin matrix to a polymer may cause variations in color changes between different restorative materials (11).

Given the clinical importance of color stability in aesthetic restorations, this narrative review aims to provide a comprehensive evaluation of the factors contributing to color changes in composite resin restorations following bleaching procedures. By synthesizing current evidence, we aim to offer practical insights that can help dental professionals optimize treatment strategies and improve long-term esthetic outcomes in complex restorative cases.

2. Materials and Methods

To compile a comprehensive list of original articles concerning the impact of bleaching on the color alteration of composite resin, an electronic search was performed through PubMed (MEDLINE), Scopus, and Web of Science up to May 2025 to provide references for this narrative review. The following keywords were used for the electronic search: (bleaching OR tooth bleaching OR carbamide peroxide OR hydrogen peroxide OR tooth whitening OR whitening agents) AND (composite resin OR restorative materials) AND (discoloration OR color change). A parallel search was conducted using the Google search engine, and the reference lists of the reviewed articles were examined to identify additional relevant publications.

3. Results

Initially, 146 articles were identified from the electronic searches. After screening for duplicates, 57 articles were removed. Subsequently, we applied inclusion and exclusion criteria to refine the list. Non-available full-text articles and non-English publications were excluded from consideration. The remaining articles were assessed based on their relevance to our primary focus: investigating the effects of bleaching on composite resin discoloration. Titles and abstracts were reviewed, and those that did not meet the eligibility criteria were eliminated. Finally, 14 articles were included (Table 1).

Table 1. Characteristics of studies included in the review.

Number	Author	Year	Title	Method	Result	Conclusion
1	Chen et al. (12)	2024	Effect of aging and bleaching on the color stability and surface roughness of a recently introduced single-shade composite resin	Thirty specimens each of a single-shade composite resin (Charisma Diamond One, CDO) and three multi-shade composite resins (Tetric NCeram, Filtek Z350 XT, Clearfil Majesty Posterior) were subjected to aging procedures involving immersion in distilled water, coffee, or water thermocycling, followed by in-office bleaching	All materials tested showed changes in color (ΔE00)	single-shade composite resin (Charisma Diamond One, CDO) showed more pronounced color change
2	Farahani et al. (13)	2023	Effect of laser and conventional office bleaching and polishing on the color change of stained nanohybrid and microhybrid composite resin	Twenty-four discs each of a microhybrid composite (Clearfil AP-X) and a nanohybrid composite (Grandio) were immersed in coffee for seven days, then divided into three groups for stain removal using bleaching, diode laser irradiation, and polishing. Color measurements: spectrophotometer.	In the Clearfil composite group, mean ΔE values after in-office bleaching, laser irradiation, and Sof-Lex polishing were 3.31, 3.35, and 4.93, respectively, while for Grandio they were 3.31 6.35, and 4.57, with in-office bleaching showing the greatest stain removal capacity and Grandio exhibiting significantly greater color changes than Clearfil ($P< 0.05$).	Both composite resins exhibited color changes after immersion in the discoloring solution. However, after staining-removing procedures the ΔE values decreased. Decreases in the ΔE values were not sufficient to restore the color to that before immersion in the discoloring solution with any stain-removing methods.
3	Korać et. al (14)	2022	Color stability of dental composites after immersion in beverages and performed whitening procedures	The color stability of microhybrid Z250 and nanocomposite Z550 was assessed after 30 days of immersion in instant coffee, tea, Coca-Cola, or deionized water, followed by 14 days of treatment with 16% carbamide peroxide. Color measurements: spectrophotometer	The tested resin composites exhibited significant color changes exceeding the acceptability threshold ($\Delta E^* > 3.48$) after immersion in coffee and tea, with the nanocomposite showing increased discoloration in coffee after 30 days,	Whitening proved to be an effective method for eliminating surface discoloration in these restorations

					while both materials effectively regained their color after treatment with 16% carbamide peroxide	
4	Hussain et al. (15)	2021	The effect of staining and bleaching on the color of two different types of composite resin restoration	Fifteen discs each of Filtek™ Z350 XT and Brilliant EverGlow composites underwent baseline color measurements, were stored in distilled water, tea, or coffee for 3 hours daily over 40 days, followed by a second color measurement, bleaching with 40% H2O2, and a final color measurement	All groups exhibited significant color changes ($\Delta E > 3.3$), with Filtek™ Z350 XT discs in coffee showing the highest change and Brilliant EverGlow discs in distilled water the least	Both materials were prone to staining in the three solutions, with Filtek™ Z350 XT being more susceptible than Brilliant EverGlow, and while in-office bleaching reduced some surface staining, it did not restore the composites to their original color
5	Amengual-Lorenzo et al. (16)	2019	Effect of two whitening agents on the color of composite resin dental restorations	A total of 20 human molar specimens obturated with Vita hybrid nanocomposite randomly divided to two groups: O1 and O2. Twenty composite discs were divided into two groups: D1 and D2. The groups O1 and D1 were treated with 16% CP, while groups =2 and D2 were treated with 37.5 % HP. Color measurements: spectrophotometer	Significant differences in color coordinates were found for Group O1 (16% CP) in L* and a*, and for Group O2 (37.5% HP) in all three coordinates, while Groups D1 and D2 only showed differences in L*	Hydrogen peroxide causes significantly greater color changes to composites used for dental restoration than composite disc specimens
6	Kamangar et al. (17)	2013	Effects of 15% carbamide peroxide and 40% hydrogen peroxide on the microhardness and color change of composite resin	Fifty-four disc-shaped specimens (A3 shade) made from Filtek P90, Filtek Z350XT Enamel, and Filtek Z250 were divided into subgroups for immersion in distilled water or exposure to Opalescence Boost or Opalescence PF for two weeks. Color measurements: spectrophotometer	Although no significant differences were found in ΔE of composites, ΔE of all groups did not remain in the clinically acceptable range after bleaching except for P90 after bleaching with 40% H2O2 ($\Delta E < 3.3$)	Composite resin color change was not significant except P90 after bleaching with 40% H2O2
7	Torres et al. (18)	2012	Influence of hydrogen peroxide bleaching gels on color, opacity, and fluorescence of composite resins	A total of 210 specimens of seven composite resin brands were fabricated, with 30 specimens for each brand. Each composite resin group was divided into three subgroups (n=10) for bleaching therapy: subgroup 1 received 20% hydrogen peroxide gel, subgroup 2 received 35% hydrogen peroxide gel, and subgroup 3 (control) was immersed in deionized water without bleaching treatment. The statistical analysis: two-way analysis of variance (ANOVA) and Tukey tests, with the level of significance at 5%	Two-way ANOVA revealed significant differences in color analysis due to bleaching therapies ($P < 0.0001$) with no significance for composite resin type ($P = 0.3006$)	The composite resin type did not affect discoloration, but the bleaching regimen did
8	Gurbuz et al. (19)	2012	Effect of at-home whitening strips on the surface roughness and color of a composite resin and an ormocer restorative material	A total of 20 specimens of two composite resin: nanofilled resin composite and ormocer. 6.5% hydrogen peroxide whitening strip were used. measurements: profilometer and colorimeter	E values (before/after whitening) calculated for composite (11.9) and ormocer (16.1) were not significantly different from each other ($P > 0.05$)	Composite resin Color change after bleaching was not significant
9	Kurtulmus-Yilmaz et al. (11)	2012	The effect of home-bleaching application on the color and	Thirty disc-shaped specimens from five resin composites (Reflexions,	Clinically unacceptable color change was detected for all resin	There was a significant and clinically

			translucency of five resin composite	Grandio, Gradia Direct, Clearfil Majesty Esthetic, Ceram-X Mono) were divided into three subgroups for treatment with carbamide peroxide, hydrogen peroxide, or distilled water as a control. Color measurements: spectrophotometer	composites exposed to bleaching agents and there was significant color difference between the control group and bleached specimens ($P< 0.05$).	unacceptable color change. The highest color difference was detected in ormocer based nano-hybrid resin composite (CXM)
10	Kwon et al. (8)	2010	Effect of hydrogen peroxide on microhardness and color change of resin nanocomposite	Three resin nanocomposites with different shades were treated for three weeks using one of three protocols involving carbamide peroxide, hydrogen peroxide, or continuous immersion in distilled water, followed by measurements of microhardness and color changes. Color measurements: spectrophotometer	In the same resin product, the decrease was similar regardless of the test agents used. In most cases, the color change was only slight ($E^*=0.5\sim1.4$)	Hydrogen peroxide enhanced the color change but the absolute color change values were similar in the same product and shade, regardless of the test agent used
11	Anagnostou et al. (10)	2010	Effect of tooth-bleaching methods on gloss and color of resin composites	A total of 24 specimens of two composite resin: a hybrid and a nanohybrid composite resin was used with the regimen of 10% carbamide peroxide gel, 6.5% and 14% hydrogen peroxide. Color measurements: Color changes using CIE-L*a*b* system	Color alteration was below the 50:50% acceptability threshold and it was product-depended. After 1- and 2-week bleaching period the nanohybrid resin composite provided statistically higher color change than the hybrid under all the bleaching procedures ($P< 0.05$)	Just hybrid composite resin showed significant color change
12	Pruthi et al. (20)	2010	Effect of bleaching on color change and surface topography of composite resin restorations	A total of 30 specimens of three composite resin brands were fabricated. Bleaching regimen: 15% carbamide peroxide bleaching solution for 8 hours per day for 14 consecutive days at room temperature. Color measurements: spectrophotometer using CIELAB color scale and Gonioreflectometer	Color change was significant in Filtek Z350 and Esthet X but not in Admira	Type of composite resin affects color change. Nanohybrid composite resin showed more color change
13	Silva Costa et al. (21)	2009	Effect of four bleaching regimens on color changes and microhardness of dental nanofilled composite resin	A total of 25 specimens of one type nanocomposite resin randomly divided into 5 groups: artificial saliva at 37°C, 7% hydrogen peroxide, 35% hydrogen peroxide, 10% carbamide peroxide, 35% carbamide peroxide. Color measurements: spectrophotometer using CIELAB color scale	Color measurements revealed no statistically significant differences in ΔE values among the four bleaching regimens for nanofilled composite resin.	color change in the nanofilled composite resin after bleaching were not significant
14	Li et al. (22)	2009	Colour and surface analysis of carbamide peroxide bleaching effects on the dental restorative materials in situ	A total of 36 volunteers were included. Nanocomposite resin, polyacid-modified composite resin, packable composite resin and glass-ionomer cement were used. 15% carbamide peroxide at-home bleaching system was performed. Color measurements: spectrophotometer	The study showed that there were significant color changes in tooth-colored materials compared to teeth over time. Initially, color changes were noticeable after bleaching, particularly between the start (T0) and the first follow-up (T1) for all materials	The bleaching effects on the materials were significantly less than those on the natural teeth

To ensure the quality and applicability of the studies, we selected only those that met specific criteria: (1) studies that investigated the effects of either at-home or in-office bleaching regimens; (2) studies that included clinical or preclinical research on various types of composite resins; and (3) studies that measured color change according to standardized methods.

After applying these criteria, 14 articles were ultimately chosen for review. This selection process was crucial to ensure the included studies were relevant, methodologically sound, and provided valuable insights into our research question. The final selection of 14 full-text English articles represents a focused and high-quality subset of the literature that effectively addresses the broader question of how bleaching impacts color change in composite resins (Figure 1).

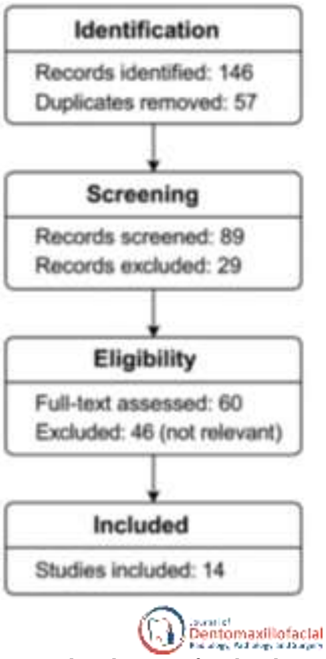

Figure 1. Flow diagram of study selection.

4. Discussion

Following a careful analysis of the selected articles, the possible and potential factors affecting color changes in dental restorations through the bleaching process were identified as follows:

The choice of bleaching method plays a significant role in the effectiveness of color change. At-home bleaching is popular for its cost-effectiveness and convenience, while in-office bleaching uses higher concentrations for more pronounced results. For instance, Amengual et al. (16) demonstrated significant differences in color change between restorations treated with a 37.5% hydrogen peroxide in-office system compared to a 16% carbamide peroxide at-home system. While many studies indicate that in-office bleaching is generally more effective, the reasons for this disparity whether due to the bleaching system itself or variations in agent concentration remain unclear and warrant further investigation (16,23).

The type of bleaching agent also affects color change. Hydrogen peroxide and carbamide peroxide are the most common agents, each with distinct acidities and compositions. Research shows that 10% hydrogen peroxide often results in a more noticeable color change than 10% carbamide peroxide; however, some studies found no significant clinical difference between the two agents (7,11,16,17,21). This inconsistency suggests that factors such as the composition of the composite resin may influence outcomes. Additionally, polishing techniques for nanofilled composites can enhance color stability and reduce staining (24).

The wide range of concentrations used in bleaching gels complicates the assessment of their effects. This review considered hydrogen peroxide concentrations from 6.5% to 40% and carbamide peroxide from 10% to 35%. In a study conducted by Torres et al. (18), the influence of hydrogen peroxide bleaching gel on the color of 7 different composite resins was evaluated. Compared with 20% hydrogen peroxide, 35% hydrogen peroxide resulted in greater color variation. Additionally, only this concentration yielded clinically acceptable color change as a result. Anagnostou et al. (10) reached the same conclusion with respect to the carbamide peroxide concentration. Moreover, increased concentrations have been shown to have a greater effect on color change, which was proven in another study (16). Conversely, Silva Costa et al. (21) reported no significant difference between higher and lower concentrations, highlighting the need for a more nuanced understanding of concentration effects.

The composition of composite resins plays a crucial role in determining their color stability after bleaching. Composite resins can be classified as nanofilled, nanohybrid, or microhybrid based on factors such as particle size, filler distribution, and filler content (25). Research suggests that these characteristics significantly impact the materials' susceptibility to color change, particularly the size of filler particles and the depth of polymerization, along with the types of coloring agents used (26). Generally, studies indicate that nanofilled composites tend to exhibit better color stability compared to microfilled composites (27).

However, findings are not universally consistent. For instance, in the study by Kurtulmus-Yilmaz et al. (11), an Ormocer-based nanohybrid composite resin showed a greater color change than a microhybrid composite resin. Conversely, Pruthi et al. (20) reported significant color changes in nanoparticle and microhybrid resins, while Ormocer-based nanohybrids exhibited minimal change. These discrepancies highlight the complexity of how different materials respond to bleaching, and indicate that further analysis is needed to pinpoint the factors contributing to these variations.

Additionally, Torres et al. (18) and Mohammadi et al. (28) found no statistically significant differences in color change among different composite types, suggesting that the context of each study such as the specific bleaching protocol or environmental factors may influence outcomes. This raises questions about the consistency of findings across diverse studies, emphasizing the importance of standardizing methodologies in future research.

Research by Chen et al. (12) demonstrated that both single-shade and multishade composite resins undergo color changes with bleaching; however, single-shade resins showed more pronounced alterations. The investigation by Anagnostou et al. (10) indicated that hybrid resins experiencing lesser color change effects compared to nonhybrid ones. In stark contrast, the study by Korać et al. (14) found that an at-home bleaching regimen using 16% carbamide peroxide had minimal effects on the basic color of all composite resins evaluated, suggesting a potential threshold effect of bleaching agents on color stability.

The in vitro findings of Hussain et al. (15) highlighted that a 40% hydrogen peroxide solution significantly impacted the color of both nanoparticle composite resins and nanohybrid ormocer materials. Notably, the nanohybrid ormocer demonstrated reduced susceptibility to staining post-bleaching, suggesting that different materials may confer varying aesthetic outcomes in the long term. The work of Farahani et al. (13) further supports this notion, revealing that nanohybrid composites exhibit greater color changes than microhybrid types, underscoring the necessity for clinicians to consider resin type when selecting materials for aesthetic restoration.

In summary, while several studies provide insights into the color stability of composite resins post-bleaching, contradictions persist in the literature. These discrepancies call for more comprehensive investigations that take into account various factors such as material composition, bleaching methods, and specific application protocols. By addressing these gaps, future research can clarify the relationships between these elements and enhance our understanding of how best to achieve aesthetic outcomes in restorative dentistry.

The frequency and interval of bleaching agent applications is another essential factor that has been relatively underexplored. The study by Li et al. (22) indicated notable differences in color change among various types of composites over different application intervals. In particular, polyacid-modified composite resins exhibited distinct color changes when assessed weekly, contrasting with packable and nanocomposite resins.

Similarly, when evaluating Ormocer-based and microhybrid composite resins against nanoparticle resins over 14-day intervals, significant color changes were observed (27). These findings suggest that the timing of bleaching applications can significantly impact color stability and outcomes.

The comparative study by Amengual-Lorenzo et al. (16) underscored significant differences in the effects of bleaching agents on composite resins used in class V cavity preparations on natural molars versus fabricated composite resin discs. While the restorative materials showed substantial color changes, the luminosity of the composite discs was minimally affected. This disparity suggests that the bleaching effects on natural teeth can differ markedly from those on restorative materials, potentially complicating clinical practices aimed at achieving optimal aesthetic outcomes. This conclusion aligns with findings of the study by Li et al. (22), reinforcing the need to consider the unique characteristics of natural teeth when assessing the efficacy of bleaching treatments on restorative materials.

Taken together, the main variables affecting composite resin discoloration after bleaching include: (1) the bleaching protocol (in-office vs. at-home), (2) the concentration and type of bleaching agent, (3) the chemical and physical properties of the resin material (e.g., filler size, matrix composition), and (4) the frequency and duration of bleaching cycles. Future studies should aim to standardize evaluation protocols to clarify these relationships.

This review has several limitations. Firstly, the variability in study designs, bleaching protocols, and assessment methodologies across the included studies may affect the reliability of the conclusions drawn. Furthermore, while 14 studies were selected based on strict criteria, the relatively small number of articles limits the generalizability of the findings. Future research should establish standardized protocols to evaluate the color stability of various composite resin types under different bleaching conditions. Studies should also investigate the interactions between bleaching agents and new composite materials to create guidelines that enhance aesthetics while reducing negative effects. Moreover, longitudinal studies on the durability and clinical performance of composite restorations following multiple bleaching treatments are essential for informing clinical practice.

5. Conclusions

The variability of results across studies highlights the complex interplay among bleaching methods, bleaching agent concentrations, application frequency, and the properties of restorative materials versus natural dental tissues. The choice of bleaching technique plays a critical role in clinical outcomes. In-office bleaching methods generally result in more pronounced color changes than at-home approaches, likely due to the use of higher concentrations of active agents. Among commonly used bleaching agents, hydrogen peroxide typically induces greater color alteration than carbamide peroxide, although this effect is highly dependent on concentration and protocol. While higher concentrations are generally associated with more significant color change, some studies report inconsistent results, suggesting the influence of additional variables. Restorative material composition also significantly affects color stability. Nanofilled composites have shown better resistance to discoloration compared to microfilled resins. However, under certain conditions—such as high-concentration (40%) hydrogen peroxide used in in-office procedures—even Ormocer-based nanohybrid composites may exhibit substantial color changes. Overall, these findings underscore the need for clinicians to consider multiple interrelated factors—bleaching method, agent type and concentration, material composition, and clinical protocol—when evaluating the potential impact of bleaching on composite resin restorations. Future standardized research is needed to clarify the interactions among these variables and support evidence-based aesthetic decision-making.

Ethical Considerations

Not applicable.

Funding

None.

Authors' Contributions

Mahsa Koochaki: Supervision, Writing – Review & Editing **Parisa Rahimirad**: Validation, Writing-Original Draft **Mohammadamin Shakerinia**: Writing-Original Draft, Supervision **Hoorieh Alsadat Hoseini Basti**: Supervision, Conceptualization **Yasaman Sadeghi**: Conceptualization **Mona Shameli**: Methodology, Writing- Original Draft, Supervision, Writing – Review & Editing.

Conflict of Interests

The authors declare no conflicts of interest.

Availability of data and material

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgments

None.

References

1. Akarslan ZZ, Sadik B, Erten H, Karabulut E. Dental esthetic satisfaction, received and desired dental treatments for improvement of esthetics. Indian J Dent Res. 2009;20(2):195-200. [DOI: 10.4103/0970-9290.52902] [PMID]
2. Alqahtani MQ. Tooth-bleaching procedures and their controversial effects: A literature review. Saudi Dent J. 2014;26(2):33-46. [DOI: 10.1016/j.sdentj.2014.02.002] [PMID] [PMCID]
3. Dobrzyński W, Piszko PJ, Kiryk J, Kiryk S, Michalak M, Kotela A, et al. Dental resin composites modified with chitosan: a systematic review. Mari Drugs. 2025;23(5):199. [DOI: 10.3390/md23050199] [PMID] [PMCID]
4. Hajisadeghi S, Khansari M, Yazdanian M, Keykha E. Effect of whitening dentifrice on discoloration of tooth surface: an updated systematic review and meta-analysis. BMC Oral Health. 2025;25(1):610. [DOI: 10.1186/s12903-025-05851-4] [PMID] [PMCID]
5. Gkavela G, Kakouris V, Pappa E, Rahiotis C. Effect of bleaching agents on healthy enamel, white spots, and carious lesions: a systematic review and meta-analysis. Dent J. 2024;12(5):140. [DOI: 10.3390/dj12050140] [PMID] [PMCID]
6. Mounika A, Mandava J, Roopesh B, Karri G. Clinical evaluation of color change and tooth sensitivity with in-office and home bleaching treatments. Indian J Dent Res. 2018;29(4):423-7. [DOI: 10.4103/ijdr.IJDR_688_16] [PMID]
7. Canay Ş, Çehreli MC. The effect of current bleaching agents on the color of light-polymerized composites in vitro. J Prosthet Dent. 2003;89(5):474-8. [DOI: 10.1016/S0022391303001689] [PMID]
8. Kwon YH, Shin DH, Yun DI, Heo YJ, Seol HJ, Kim HI. Effect of hydrogen peroxide on microhardness and color change of resin nanocomposites. Am J Dent. 2010;23(1):19. [PMID]
9. Hubbezoglu I, Akaoglu B, Dogan A, Keskin S, Bolayir G, ÖZÇELIK S, et al. Effect of bleaching on color change and refractive index of dental composite resins. Dent Mater J. 2008;27(1):105-16. [PMID]
10. Anagnostou M, Chelioti G, Chioti S, Kakaboura A. Effect of tooth-bleaching methods on gloss and color of resin composites. J Dent. 2010;38:e129-36. [DOI: 10.1016/j.jdent.2010.06.006] [PMID]
11. Kurtulmus-Yilmaz S, Cengiz E, Ulusoy N, Ozak ST, Yuksel E. The effect of home-bleaching application on the color and translucency of five resin composites. J Dent. 2013;41:e70-5. [DOI: 10.1016/j.jdent.2012.12.007] [PMID]
12. Chen S, Zhu J, Yu M, Jin C, Huang C. Effect of aging and bleaching on the color stability and surface roughness of a recently introduced single-shade composite resin. J Dent. 2024;143:104917. [DOI: 10.1016/j.jdent.2024.104917] [PMID]
13. Farahani S, Faghihi T, Ranjbar Omrani L, Chiniforush N, Ahmadi E, Karimi M, et al. Effect of laser and conventional office bleaching and polishing on the color change of stained nanohybrid and microhybrid composite resin. Int J Dent. 2023;2023(1):9912560. [DOI: 10.1155/2023/9912560] [PMID] [PMCID]
14. Korać S, Ajanović M, Tahmiščija I, Džanković A, Konjhodžić A, Glamoč AG, et al. The effect of bleaching on the basic colour and discoloration susceptibility of dental composites. Acta Med Acad. 2021;50(3):397-405. [DOI: 10.5644/ama2006-124.361] [PMID]
15. Hussain SK, Al-Abbasi SW, Refaat MM, Hussain AM. The effect of staining and bleaching on the color of two different types of composite restoration. J Clin Exp Dent. 2021;13(12):e1233. [DOI: 10.4317/jced.58837] [PMID] [PMCID]
16. Amengual-Lorenzo J, Montiel-Company JM, Bellot-Arcís C, Labaig-Rueda C, Solá-Ruiz MF. Effect of two whitening agents on the color of composite dental restorations. J Clin Exp Dent. 2019;11(1):e15. [DOI: 10.4317/jced.55450] [PMID] [PMCID]
17. Kamangar SS, Kiakojoori K, Mirzaii M, Fard MJ. Effects of 15% carbamide peroxide and 40% hydrogen peroxide on the microhardness and color change of composite resins. J Dent (Tehran, Iran). 2014;11(2):196-209. [PMID] [PMCID]
18. Torres CR, Ribeiro CF, Bresciani E, Borges AB. Influence of hydrogen peroxide bleaching gels on color, opacity, and fluorescence of composite resins. Oper Dent. 2012;37(5):526-31. [DOI: 10.2341/11-189-L] [PMID]
19. Gurbuz A, Ozkan P, Yilmaz K, Yilmaz B, Durkan R. Effect of at-home whitening strips on the surface roughness and color of a composite and an ormocer restorative material. J Prosthodont. 2013;22(1):69-73. [DOI: 10.1111/j.1532-849X.2012.00918.x] [PMID]
20. Pruthi G, Jain V, Kandpal HC, Mathur VP, Shah N. Effect of bleaching on color change and surface topography of composite restorations. Int J Dent. 2010;2010(1):695748. [DOI: 10.1155/2010/695748] [PMID] [PMCID]

21. Silva Costa SX, Becker AB, de Souza Rastelli AN, Monteiro Loffredo LD, de Andrade MF, Bagnato VS. Effect of four bleaching regimens on color changes and microhardness of dental nanofilled composite. Int J Dent. 2009;2009(1):313845. [DOI: 10.1155/2009/313845] [PMID] [PMCID]

22. Li Q, Yu H, Wang Y. Colour and surface analysis of carbamide peroxide bleaching effects on the dental restorative materials in situ. J Dent. 2009 ;37(5):348-56. [DOI: 10.1016/j.jdent.2009.01.003] [PMID]

23. Monaghan P, Trowbridge T, Lautenschlager E. Composite resin color change after vital tooth bleaching. J Prosthet Dent. 1992;67(6):778-81. [DOI: 10.1016/0022-3913(92)90581-t] [PMID]

24. Kayalidere EE, Dorter C. Effects of in-office bleaching agents on polished and unpolished nanofilled resin composite. J Am Dent Assoc. 2023;154(7):592-600. [DOI: 10.1016/j.adaj.2023.04.005] [PMID]

25. Willems G, Lambrechts P, Braem M, Celis JP, Vanherle GJ. A classification of dental composites according to their morphological and mechanical characteristics. Dent Mater. 1992;8(5):310-9. [DOI: 10.1016/0109-5641(92)90106-m] [PMID]

26. Ergücü Z, Türkün LS, Aladag AJ. Color stability of nanocomposites polished with one-step systems. Oper Dent. 2008;33(4):413-20. [DOI: 10.2341/07-107] [PMID]

27. Rao YM, Srilakshmi V, Vinayagam KK, Narayanan LL. An evaluation of the color stability of tooth-colored restorative materials after bleaching using CIELAB color technique. Indian J Dent Res. 2009;20(1):60-4. [DOI: 10.4103/0970-9290.49071] [PMID]

28. Mohammadi N, Kimyai S, Abed-Kahnamoii M, Ebrahimi-Chaharom ME, Sadr A, Daneshi M. Effect of 15% carbamide peroxide bleaching gel on color stability of giomer and microfilled composite resin: an in vitro comparison. Med Oral Patol Oral Cir Bucal. 2012;17(6):e1082-88. [DOI: 10.4317/medoral.17916] [PMID] [PMCID]