Review of Bleaching Effects on the Properties of Restorative Materials

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Abstract

With the increasingly commercial emphasis on dental esthetics, patients have become more interested in improving the appearance of their smile. For many, achieving whiter teeth are their chief goal. Others want to eliminate the discoloration caused by either smoking, drinking beverages or any medication. The effects of the bleaching products on dental restorative materials have been studied because of the popularity of bleaching and the addition of new bleaching products every year. Practitioners need to take certain precautions while dental bleaching. This article provides practitioners with an insight to changes occuring in restorative materials after dental bleaching.

Keywords: Bleaching, Hydrogen peroxide, Carbamide peroxide, Restorative materials.

Introduction

Tooth whitening is a popular technique used in esthetic dentistry[1], being widely accepted as an effective clinical procedure.[2] Although considered relatively safe with regard to systemic effects, recently, some controversy has arisen related to its effects on restorative materials.[1]

The effect of whitening agents on restorative materials should be analyzed for their potential deleterious consequences on physical, mechanical and corrosive properties. The changes in materials properties may have important clinical implications, since the prognosis and the longevity of a dental restoration may depend upon them.[3] Advice is provided based on the current literature to minimize the impact of bleaching therapies on restorative materials. This article also reviews their conclusions, focusing mainly on the clinical impact these agents can have on amalgam, porcelain, ormocer, glass ionomer, compomer, composite resin restorations and temporary restorative materials.

Bleaching has been shown to have various effects on existing restorations in a patient's mouth, as well as potential effects on restorations to be placed following bleaching. There are mixed reports on the effects of bleaching agents on existing restorative materials in the mouth. Detailed below are discussions under the headings of the various types of restorative materials.

Amalgam

Inreased Mercury Release : Regarding amalgam, the greatest point of interest and research has been Mercury, with several authors detecting an increased concentration after whitening on the restorative surface, immerging water and whitening product.[1,4,5,6,7] Nevertheless, the mercury concentration was lower than the guidelines recommended by the World Health Organization (WHO) and National Academy of Sciences. Food and Nutrition Board (NASFNB).[1] The mercury release from fillings is dependent on the duration of the whitening treatment, amalgam age, surface polishing conditions, composition and pH of the whitening agent[6] and surface area of the restoration.[6,8]

A prolonged bleaching regimen with certain home bleaching products has the potential to increase mercury release from amalgam restorations.[9] More research is necessary to determine the long-term effects of bleaching on amalgam restorations.

In another study, Rotstein et al[10] studied the effects of mercury release in vitro on four commercial brands of amalgam. The study found that amalgam restorations exposed 48 hours to 10 percent carbamide peroxide showed higher concentrations of mercury release. The implications of this study and the research[9] are twofold: First of all, mercury vapor release will vary depending on the type of amalgam as well as the type of bleaching agent applied. Secondly, the dental professional should be knowledgeable of both the recommended bleaching agent as well as the brand of amalgam used (which may not be possible in the case of patients with older, pre-existing amalgams). In fact, a study[11] suggested that not all combinations of amalgam and bleaching agents result in higher mercury vapor levels; it is likely that only specific combinations of materials produce substantial levels of mercury vapors. Also, the amount of mercury vapor released from amalgam restorations will vary substantially among individuals, particularly depending on the extent of bleaching (based on the nature of the tooth stain and personal expectations) and amount of amalgam present in the individual's mouth. Various laboratory studies have reported increased release of amalgam components, such as mercury and silver, from amalgam specimens exposed to 10% carbamide peroxide or 10% hydrogen peroxide preparations.[9,10,12]Active oxidation was held to be responsible for the increased release of amalgam components and also for greening of the tooth-amalgam interface clinically observed by Haywood[13] during extended 10% carbamide bleaching. In vitro studies showed that the amount of mercury release was dependent on both the amalgam and carbamide peroxide brand tested.[10,12,14]

In order to reduce patient exposure to amalgam components, polishing of amalgam restorations prior to starting of a bleaching therapy should be performed to reduce corrosion potential of the amalgam restorations. The mercury release from amalgam seems also to be modified by the presence of biofilm on amalgam containing saliva, bacteria and polysaccharide, since an experimentally induced biofilm coating on amalgam has shown to reduce mercury release into the surrounding environment.[15] Additionally, pre-coating of amalgam surfaces with a protective varnish such as copalite (10% copal resin in a combination of ether, alcohol and acetone) seems to be advisable to reduce release of mercury into the surrounding environment during bleaching with 10% carbamide peroxide.[12]

Colour Change : Another potential risk of bleaching patients with amalgam restorations is discoloration. In a case study published earlier this year, Haywood (2002)[13] described a greening of the tooth-amalgam interface after bleaching treatment. The researcher found caries in the area of the green discoloration, which was only on a small segment of an amalgam restoration.

In a case report, intraoral bleaching with 10% CP caused some staining of the bleaching tray in areas where dental amalgam restorations presented with superficial chipping at the cavosurface margins.[16] The causes of colour change found in this case report could be linked to defective dental amalgam restorations, the composition of the bleaching agent and the dental amalgam, the presence of undiagnosed decay or a more complex interaction among these elements.

To avoid greening discoloration around dental amalgams, practitioners should meticulously examine the restorations before proceeding with bleaching and pay particular attention to the amalgams that have marginal discrepancies.

Change in Surface Texture & Hardness : Low concentration of hydrogen peroxide gels (6%) do not alter the surface texture of either high-copper amalgam or type III gold alloy.[17] However, evaluation of corrosion current density of various dental alloys revealed that the application of 10% carbamide peroxide solution on non-polished amalgam samples and nickelchromium specimens may cause corrosion of these materials, but not of noble alloys. In this study, it was also shown that the bleaching agent caused lower corrosion potential for the

polished amalgam samples compared to non-polished specimens.[18]

Concerning the surface changes, Rotstein et al.[4] and Gurgan et al.[6] concluded that slight differences in amalgam surface regularity can be observed on SEM micrographs, after application of CP and HP. Nonetheless, other two experimental studies[5, 17] have not reported surface alterations after treatment with CP and HP.

Marginal Leakage : Marginal leakage of amalgam restorations with enamel margins only were not negatively influenced by pre-operative external bleaching with 10% carbamide peroxide.[19]

Ceramic Restorations

Colour Change : No effects on the colour or physical properties of porcelain or other ceramic materials have been reported.[20,11]

Changes in Surface Texture & Hardness : A number of recent articles have studied the impact of bleaching treatment on the physical properties of ceramic restorations. Turker and Biskin (2002)[21] reported significant decreases averaging about 15% in the surface microhardness of feldspathic porcelain caused by a reduction of silicon dioxide (SiO_2) and potassium peroxide (K_2O_2) molecules on exposure to carbamide peroxide. In their study, Zaki and Fahmy[22] distinguished between autoglazed and overglazed ceramic restorations. The increased roughness of overglazed ceramic could lead to more plaque retention, bacterial adherence and gingival irritation, so the authors suggested protecting these materials with a barrier before bleaching to preserve the integrity of the ceramic surface.[8] As it is difficult for dentists to distinguish between overglazed and autoglazed ceramic restorations in the clinic, practitioners should be wise to advise patients to avoid bleaching ceramic restorations, especially those of anterior teeth.

Laboratory studies of in-office[23] (38% HP) and at-home[24] (15% CP) bleaching agents concluded that the microhardness of ceramic restorations was not affected 30 days after the end of the bleaching procedure.

Ormocer (Organically Modified Ceramic)

Colour Change : Two studies[25,26] investigated the impact of bleaching agents on the stability of the colour of ormocer restorations. Ormocers or organically modified ceramics are a combination of organic and inorganic copolymers developed to improve the results of dental restorations. Using a colorimeter, Yalcin and Gurgan[25] found a significant change in the colour of samples of ormocer exposed to 10% CP. Another study[26] that used a high (35%) concentration of HP demonstrated a significant change in colour that could necessitate the replacement of the restoration. The authors of these studies suggested that these restorations might have to be replaced after bleaching because the colour changes might be perceptible by the human eye, even though the colour changes were within a clinically acceptable range.

Change in Surface Texture & Hardness: In a study,[27] ormocers showed no significant change in microhardness with the use of a high concentration of peroxide. The authors associated these results with the high weight percentage of filler particles and the matrix of the ormocer which contains inorganic-organic copolymers. Similar results were described in 2 other studies.[23,24] As the microhardness of the ormocers remained unchanged, the authors considered bleaching a safe option that required no replacement of the restorations.

Release of Monomers : A recent article[28] reported the effect of bleaching on the elution of monomers from different dental materials. The authors found a decrease in the quantity of released bisphenol A from the bleached ormocer samples compared to the unbleached samples and concluded that bleaching ormocer restorations is not a health hazard.

Glass Ionomer Cement & Resin-Modified Glass Ionomer Cement

Increase in Solubility : It has been suggested that bleaching may increase the solubility of glass-ionomer and other cements.[29]

Colour Change : A recent in situ study by Li and colleagues[30] found a significant difference in the colour of a conventional glass ionomer cement restoration after 4 weeks of bleaching with 15% CP, over that noted before the treatment. However, 2 weeks after the whitening treatment ceased, the colour returned to that noted before the treatment, showing that bleaching did not affect the colour of the glass ionomer cement.

Change in Surface Texture & Hardness : A study[31] found alterations, such as cracks and pits, in the surface of the glass ionomer cement, which were explained by the ability of the bleaching agent to alter the surface properties of the material. The authors also found that bleached glass ionomer restorations were more susceptible to different staining solutions with a pH from 3.73 to 6.25, such as red wine, herbal tea, Coca Cola and coffee.

When using 15% CP and 35% HP on resin-modified glass ionomer cement restorations, Taher[27] found a softening effect and a significant decrease in their surface hardness. In contrast to these findings, both high and low concentrated bleaching agents did not show any influence on fluoride release of dental materials, such as conventional and resin-modified glass ionomer cements.[32] Microhardness of resin-modified glass ionomer cements increased[33] or remained stable[34] after treatment with 10% carbamide peroxide gels. Utilizing highly concentrated bleaching regimes, no surface microhardness changes were observed in resin-modified glass ionomer cements.[35]

Composite Resins

Colour Change : Using a spectrophotometer, Li and colleagues[30] found significant changes in the colour of nanohybrid and packable composite resins after bleaching with 15% CP. In this study, the colour change was clinically acceptable. Therefore, replacement of restorations to match the colour of bleached enamel after teeth whitening was not required.[36] For standardized and reproducible evaluation of color changes of restorative materials, colorimeters are used analyzing Lab values according to the CIELab-system.[37,38] It has been claimed that under clinical conditions in the mouth, DE color differences have been reported to be relevant and perceptible only when higher than 3.3[39]or 3.6.[40] Cooley and Burger (1991)[41] reported that with use of a colorimeter, 10 percent carbamide peroxide gels somewhat lightened the color of composite resins giving statistically significant results, but all the changes were not seen clinically. Differences in color change between different materials might be a result of different amount of resin and different degrees of conversion of the resin matrix to polymer.[42]

Change in Surface Texture & Hardness : Using the Knoop hardness test, Hannig and colleagues[43] reported a significant decrease in the surface hardness of bleached composite resins, not only on superficial surfaces, but in the deeper layers of the filling materials as well. Similarly, another research study[27] concluded that bleaching with different peroxide concentrations significantly decreased the surface microhardness of a microfilled composite resin.

A recent study by Wattanapayungkul and colleagues[3] demonstrated that treating composite resins with a low peroxide concentration significantly increased their surface roughness. Wattanapayungkul et al.[3] concluded that the effect of whitening agents on surface roughness of composites is dependent on the specific material tested and time with higher concentrations of HP causing higher roughness. Another study[44] that evaluated the effect of low and high peroxide concentrations on hybrid and microfilled composite resins came to a similar conclusion. In these cases, repolishing or replacing these restorations may be necessary after long periods of whitening treatment to allow the reestablishment of the esthetic properties and to prevent the colonization of cariogenic microorganisms.[3,18,23]

Garcia-Godoy (2002)[45] used surface profilometry & micro-hardness measurement as a baseline before bleaching, the bleaching gels were then used according to manufacturer instructions. The authors concluded that no significant differences were found in the materials they tested, but that the effects of different bleaching agents must be tested on the different restorative

materials on the market to determine their safety on each material's surface integrity.

Langsten et al (2002)[46] evaluated changes in surface roughness of hybrid and microfilled composites after exposure with higher concentrations of carbamide peroxide. The study concluded that higher concentration carbamide peroxide bleaching products have minimal to no surface effects on hybrid or microfilled composites. Several studies have demonstrated an increase in the surface roughness of resin composites after whitening with 10% CP and/or 10% HP.[41,47,48] Furthermore, some authors[18] verified the existence of cracks visible to the naked eye with this material.

Reports on the effects of bleaching on composite resins are conflicting. Some studies have shown that composites are unaffected by the bleaching agents.[49,50] Burger and Cooley (1991)[41] reported a significant increase in the mean microhardness of microfilled, macrofilled and hybrid type composite resin after long-term exposure to carbamide solutions. Bailey and Swift (1992)[47] found the microhardness of the hybrid and microfilled composite resins to decrease. According to the surface roughening, Bailey and Swift (1992)[47] demonstrated that 10% carbamide peroxide bleaching agents, caused only slight changes to the surface of microfilled composite. The results of the study of Turker and Biskin (2003)[51] are similar to those of Bailey and Swift.

In some scanning electron microscopic studies and profilometric analysis, it was shown that 10-16% carbamide peroxide bleaching gels (i.e. 3.6-5.76% hydrogen peroxide) may lead to a slight, but statistically significant increase in surface roughness and amount of porosities of microfilled and hybrid composite resins.[47,51,52] However, analysis of surface reflectance showed significant changes in microfilled and hybrid composite resins after application of highly concentrated tooth whiteners with 30-35% hydrogen peroxide.[53] The authors suggested that the changes in surface reflectance reveal more subtle changes in the surface and perhaps also in the immediate subsurface. In this context it should also be mentioned that salivary proteins absorbed onto the surface of composite materials decreased after bleaching with peroxide containing agents, which is suggested to have an influence on bacterial adhesion of cariogenic bacteria, such as Streptococcus sobrinus and Streptococcus mutans but not of Actinomyces viscosus.[54] In some investigations softening of composite resins was associated with the application of home-bleaching gels.[47,33] Other investigations revealed no significant hardness changes[45,50] due to application of home bleaching gels or even an increase in surface hardness.[51,55]

Staining : Yu and colleagues[31] found that bleached composite resins stain more easily than unbleached ones. The authors suggested that this staining could be caused by alterations in the surface of the bleached restorations. However, one study[36] found that bleaching can remove stains from the external surface of a composite restoration, and another[56] found that bleaching with 15% HP is more effective than polishing for removing stains and restoring the original colour of the composite resin. Even 10% carbamide bleaching agents were able to remove extrinsic stains from composite restorative materials.[57]

Release of Monomer : Polydorou and colleagues,[28] in their study of the amount of monomer released from a bleached composite resin, found that less Bis-GMA (bisphenol A-glycidyl dimethacrylate) and less UDMA-2 (urethane dimethacrylate) were released from composite resin restorations than from unbleached control samples. The released concentration of TEGDMA (triethylene glycoldimethacrylate) molecules was similar to that of the control group.[28]

Bond Strength : Many investigators have reported a severe decrease in the average bond strength of composite to bleached versus unbleached enamel.[58] Also, it has been proposed that theoretically the enamel pores, dentin and dentinal fluid could act as a peroxide/oxygen reservoir resulting in oxygen concentrating on the surface of enamel and preventing the complete cure of some resin tags.[58] Some researchers have reported that only when composite was bonded immediately after bleaching completions was the bond strength significantly reduced.[59] Other researchers have given examples of ways to counteract the adverse bleaching effects so that no statistical difference in bond strength was observed. Some examples of counteracting mechanisms are exposing the enamel specimens to artificial saliva, water, or saline solution.[60] Another suggestion was to use water-clearing solvents, for example acetone, ethanol, or acetone-based adhesive systems. Finally, it has been suggested that one remove the superficial enamel layer.[61]

Various theories have been proposed to explain why the bond strength might be affected on bleached teeth. Changes in the enamel structure are one explanation. For example a loss of mineral content and increased porosity manifested as an over-etched appearance with a loss of the prismatic enamel form.[62] It has been noted that the resin tags are reduced in number, less defined and shorter in bleached enamel.[63]

Another study evaluated the effects of carbamide peroxide bleaching agent on interfaces formed by two one-bottled dental adhesives to etched enamel.[64] The results showed no significant changes in the relative oxygen concentration of the bleached and unbleached-but-etched enamel. The calcium and phosphorus content of the enamel, however, did show significantly decreased relative concentrations in the bleached enamel. Bleaching also resulted in morphological alterations in the most superficial enamel crystallites, they were short and randomly disposed and the characteristic alignment of the crystallites was lost. This study reports that no changes in the relative concentrations of oxygen were found in the enamel bleached with 10 percent carbamide peroxide.[64] This indicates that the surface roughening or removal suggested by others is not needed.

The study also questioned the role of urea in surface changes.[64] Urea may remove enamel proteins present in the intercrystallite spaces and in this process of deproteinization, any mineral elements associated with enamel proteins are also removed. This could be why a decrease in the calcium and phosphorus concentration is observed in bleached enamel. This is definitely an area that needs more research.

Marginal Leakage : Margins of restorations could be regarded as a possible pathway facilitating peroxide penetration into the pulp chamber, which is held responsible for pulpal reactions, such as increase in tooth hypersensitivity, during external bleaching of vital teeth.[65,66]

Bleaching teeth with Class I composite restorations with 20% CP does not affect the occlusal margins of the restorations and, therefore, does not cause microleakage.[67] Similar results were found at the occlusal and gingival margins of Class V restorations after they were bleached with 20% CP and 38% HP.[68] Although the findings of these studies suggest that the margins of restorations are not affected after bleaching procedures, more clinical studies are needed to show the impact of bleaching on more extensive Class II composite resin restorations.

Pre-restorative non-vital, intra-coronal bleaching in the sense of walking-bleach-technique using mixtures of 37% carbamide peroxide or pastes consisting of 30% hydrogen peroxide and sodium perborate leads to a higher rate of microleakage in composite restorations of both the access cavity and class-V cavities placed immediately after termination of bleaching[69-71] In class-V restorations, the increase of microleakage after intra-coronal application of 37% carbamide peroxide was only detected in dentin margins and not in enamel margins.[69] The rate of microleakage of restored access cavities increased with increasing duration of the application of the sodium perborate-hydrogen peroxide mixture.[71] Thereby, a 7-day application resulted in inferior sealing compared to a 1- or 4-day application. Short-term use of intracoronal calcium hydroxide medicament for 7 days after completion of walking bleach therapy was able to reverse the negative influences of the hydrogen peroxide application on microleakage of access

cavities.[70] Controversy exists about the influence of preoperative external bleaching with 10% carbamide peroxide on microleakage of composite restorations.

Crim[72] reported that 10% carbamide peroxide did not impair the marginal seal of class-V restorations placed at the cementoenamel junction. In contrast in a study, microleakage rates of labial restorations with enamel margins only were significantly increased after 10% carbamide peroxide bleaching.[19] Similar findings were reported by Turkun and Turkun[56], who observed significant reduction in sealing of access cavities with composite resins up to 1 week after application of 10% carbamide peroxide into the pulp chamber. Two studies reported that the post-operative contact of composite restorations with 35% hydrogen peroxide or 10-16% carbamide peroxide gel adversely affected the marginal seal at both dentin[73] and enamel[19] margins. In contrast, other studies did not find increased microleakage rates atleast at enamel margins.[73,74]

Compomer (Polyacid-Modified Composite Resin)

Changes in Surface Texture & Hardness : Clinical studies showed that surface roughness of compomers was clinically significantly increased when exposed to bleaching procedures. SEM showed cracks[3,31,75] and chemical alterations and surface dissolution[30] in the restorations after their exposure to 10% and 15% CP. One study[3] related these results to filler-matrix debonding at the surface of the compomer, caused by free radicals from the peroxide. However, a total of three 30-min bleaching sessions conducted at 1-week intervals, as recommended by the manufacturers, did not result in detrimental effects of the surface finish of compomers. Rosentritt and colleagues[75] found that compomers deteriorated and decreased in hardness after they were bleached. In another study,[43] subsurface analysis of bleached compomers showed that layers up to 2 mm deep were affected because of significantly reduced hardness and that the filling materials appeared softened. Because these results were clinically significant, the authors suggested that it might be necessary to replace or polish compomer restorations after bleaching.

Increased Fluoride Release : Highly concentrated bleaching regimes induced an increase in fluoride release of polyacid-modified resin-based composites (compomers) when those bleaching agents were continuously applied for 15 days.[76,77]

Colour Change : Researchers[30,31,75] studying the effect of bleaching on the colour of compomer restorations concluded that bleaching with 10% to 15% CP causes a significant change that could be related to surface alterations, as Li and colleagues[30] showed with SEM. A recent study[31] of compomer restorations reported their increased susceptibility to staining with red wine, coffee and Coca Cola after bleaching with 15% CP.

The occurrence of visible color changes in compomers treated with 10% carbamide peroxide were likewise, the changes in surface texture, dependent on the brand tested, whereas treatment with 10 and 30% hydrogen peroxide resulted in noticeable color change irrespective of the compomer material evaluated.[78]

Temporary Restorations

Change in Surface Texture & Colour : Hydrogen peroxide and carbamide peroxide both cause microscopic changes to IRM restorations. Also, hydrogen peroxide may cause macroscopic changes to IRM, resulting in cracking and swelling. On the other hand, IRM appears unaffected by carbamide peroxide on the macroscopic level.[20,11] Polycarbonate crowns and bis-acryl composite temporary restorations do not discolor upon bleaching.[11]

Jefferson et al.[79] described a decrease in aluminum and an increase in porosity in zinc oxide cement after immersion in acidic 10% carbamide peroxide solutions.

Conclusion

Bonding of adhesively attached restorations to prebleached dental hard tissue is significantly reduced. Therefore, it is recommended to delay placement of restorations after termination of bleaching therapy for at least 13 weeks. Additionally, bleaching therapies with hydrogen peroxide or hydrogen peroxide releasing preparations may have a negative effect on restorations and restorative materials as shown in numerous in vitro investigations. It remains unclear in how far those observations may result in significant deterioration of restorations under clinical conditions. Further investigations are necessary to elucidate these aspects more precisely. Given the availability of 2 types of peroxide in multiple concentrations, the lack of consensus about the effects of bleaching agents on restorative materials among the authors of the laboratory studies reviewed in this article is not surprising. Dentists should be aware that the physical properties of some dental restorations may be altered after bleaching. They should also make sure that their patients with dental restorations are aware of the changes that may occur during whitening, as well as the possibility that their bleached restorations may need to be polished or replaced at the end of the treatment.

References

References are available on request at editor@healtalkht.com

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