REVIEW ARTICLE

e-ISSN: 2349-0659 p-ISSN: 2350-0964
doi: 10.21276/apjhs.2018.5.1.31

Mechanism of action and clinical effects of teeth whitening on enamel and dentin bonding for resin-based restorations

Karishma Vijan[1,2,3]

[1]Consultant Specialist and Private Practitioner, Mumbai, Maharashtra, India, [2]School of Dental Medicine, Bharati Vidyapeeth University Dental College and Hospital, Navi Mumbai, Maharashtra, India, [3]Department of Aesthetic and Restorative Dentistry, University of Manchester, England, United Kingdom

ABSTRACT

The yellow, dull, and discolored permanent anterior teeth are a common esthetic dilemma and require competent solutions. This article deals with the mechanism and clinical effects of teeth whitening on enamel and dentin bonding efficacy.

Key words: Bleaching, dentin, enamel, extrinsic, intrinsic, resin bonding, restorations, stainssaliva, teeth, whitening

INTRODUCTION

The yellow, dull, and discolored permanent anterior teeth are a common esthetic dilemma and require competent solutions. In the past few years, teeth whitening has become a prevailing solution to the common esthetic problems. Tooth discoloration can differ in etiology, appearance, localization, severity, and adherence to tooth structure. It may be classified as intrinsic, extrinsic, and a combination of both[1] intrinsic discoloration occurs due to embedded chromatogenic substances into enamel and dentine during odontogenesis or post tooth eruption. Preeruption discoloration can be caused by exposure to high levels of fluoride, tetracycline administration, genetic developmental disorders, and tooth trauma. Posteruption of the tooth, aging, pulpal necrosis, and iatrogenesis is the main causes of intrinsic discoloration. Coffee, tea, red wine, carrots, oranges, and tobacco give rise to extrinsic stain.[1,2] Tooth wear, deposition of secondary dentin due to aging, or as a consequence of pulp inflammation, and dentin sclerosis affects the light-transmitting properties of teeth, resulting in a gradual darkening of the teeth. Scaling and polishing of the teeth remove many extrinsic stains. For more stubborn extrinsic discoloration and intrinsic stain, various bleaching techniques may be attempted. Tooth bleaching can be performed externally, termed nightguard vital bleaching or vital tooth bleaching, or intra-coronally in root-filled teeth, called non-vital tooth bleaching. However, some studies have shown that the bond strength of bonded restorations to tooth structures is reduced when the tooth has been bleached, using either an in-office or at-home technique.[3-7]

THE INFLUENCE OF BLEACHING AGENTS ON BOND STRENGTH OF ENAMEL SUBSTRATE

Even though the procedure for in-office bleaching and at-home bleaching is dissimilar, the primary active agent for each of them remains hydrogen peroxide (HP). The at-home bleaching Kit uses 10–17% carbamide peroxide (CP) which further dissociates into HP; (6%) and urea; (11%) when it contacts with soft tissues or saliva at oral temperatures.[4,5] The in-office bleaching solution on the other hand comprises 35% HP in its direct form.[6,8] As a fact well established, H_2O_2 is a strong oxidant and also acidic in nature. One of the contemplated mechanisms of action of the bleaching agents is assumed to be due to the ingenuity of HP releasing oxygen free radicals. These free oxygen radicals further interact with the adsorbed colored organic molecules and oxidizes these macromolecules and pigment stains, which produce dental discoloration, into smaller and lighter molecules. The oxidative process, with its low resulting pH, has been considered as a potential source of adverse effects,[7] thus through the nondestructive Fourier-transform infrared spectroscopic technique, it has been observed that office bleaching can cause a significant reduction in tooth mineralization. In addition, it has been proven that the protein and polysaccharide concentrations and mineral-to-protein ratio reduced considerably while the proteins were denatured in office-bleached enamel. However, in at-home bleaching samples, no quantitative changes were observed either in the macromolecular concentrations or in the mineral matrix ratio and protein secondary structure. The main limitation of this study, however, was that the bleaching

Address for correspondence:
Karishma Vijan, Department of Aesthetic and Restorative Dentistry, University of Manchester, England, United Kingdom. E-mail: drkarishma.vijan@gmail.com

Received: 10-01-2018 **Revised:** 26-01-2018 **Accepted:** 04-03-2018

procedures were carried out in the absence of saliva. It is known that natural saliva remineralizes the teeth after the bleaching process.[8] However, the adverse effect of decreasing bond strengths is eliminated when the enamel surface is roughened. It has been suggested that residual oxygen from the bleaching agent inhibits resin polymerization. However, a recent study using energy-dispersive spectroscopy showed that CP does not elicit changes in the relative concentration of oxygen on the surface of enamel. This is in agreement with other surface analysis techniques that have demonstrated that oxygen does not accumulate within the near surface of enamel that has been bleached with HP. Consequently, the reduction in bond strength caused by bleaching may not be related to inhibition of resin polymerization by oxygen accumulation within the enamel structure. However, it could be caused by the accumulation of oxygen in dentin since dentin may act as an important oxygen reservoir.[9]

Therefore, further studies investigating the role of natural saliva in bleaching-induced structural changes in teeth should be carried out. Under the scanning electron microscope, interfaces between resin and 35% HP-bleached enamel substantially different from those formed between resin and unbleached enamel poorly defined resin tags, porous and granular tag surfaces, and areas of resin debonding compared to interfaces with unbleached enamel.[9] The bleaching agents used in tooth whitening techniques cause oxygen to be released and can cause morphologic alterations in the mineralized structures.[10-12] Alterations on the enamel surface are attributed to the modification of its inorganic composition after treatment with peroxide-based bleaching agents.[11] These changes in the chemical composition of the enamel considerably diminish the amount of calcium and phosphorous in addition to modifying the morphology of the majority of crystals of the surface layer when compared with enamel not submitted to bleaching.[12,13]

THE INFLUENCE OF BLEACHING AGENTS ON BOND STRENGTH OF DENTINAL SUBSTRATE

The action mechanism of teeth whitening occurs through a complex oxidation reaction in which HP solution with a low-molecular-weight (34 g/mol) is deposited on the tooth enamel and activated by either heat or light radiation depending on the used bleaching system. The HP then decomposes into water and nascent oxygen with the latter penetrating rapidly through the enamel porosities and the organic matrix of the enamel and dentin. The oxygen reacts promptly with pigments, possibly causing weak links between the chromatogenic molecules and the organic matrix to rupture. The chromophoric molecules are oxidized by the nascent oxygen ions and are broken down into smaller, less complex, and lighter molecules. However, as seen above, studies have proven that the strength of dentine bonding strengths is reduced significantly, when bonding is performed immediately after bleaching the teeth, for both at-home and for in-office bleaching procedures. In-dentin alterations are also observed due to the presence of residual oxygen that prevents polymerization of the resin. The reduction in bond strength is important since the presence of oxygen released by the bleaching processes inhibits polymerization of the adhesive systems and is responsible for compromising the bond strength between the restorative material and the dental substrate.[14-16]

The residual oxygen accumulates not only on the bleached enamel surface but also within the dentinal structure - more precisely on the collagen matrix and in the dentinal tubules.[15] This may cause difficulties with resin composite penetration and its polymerization.[17,18] Consequently, the reduction in bond strength caused by bleaching agents is related not only to inhibition of resin polymerization due to the accumulation of oxygen on the enamel structure alone but also because of its accumulation within the dentinal structure.[19] However, this reduction in bond strength after bleaching treatment is time dependent, and the damage is greater when the bond strength tests are performed immediately after the use of bleaching agents. Nevertheless, bond strength values return to normal after a few days when the residual oxygen is liberated, thus reducing the undesirable effects.[20] As a result of this phenomenon, it is important[17,18] to verify the bond strength of composite resin to enamel and dentin as well as the influence of waiting time before performing restorative procedures after in-office dental bleaching treatments are done. The use of HP at high concentrations (30–35%) is one of the most common bleaching techniques done in the dental office. However, when dentin is exposed to the oral environment, such as in cervical lesions and veneer preparations that extend into dentin, 1 week of elapsed time between bleaching and restorative treatment significantly increases bond strengths [Figure 1].

THE EFFECTIVE TIME INTERVAL BETWEEN TEETH WHITENING AND RESIN-BASED RESTORATIONS

The literature has reported that bonding to recently bleached enamel may be impaired, regardless of the type, and concentration of bleaching agent. The present study revealed reduced penetration of the adhesive system, with the formation of small

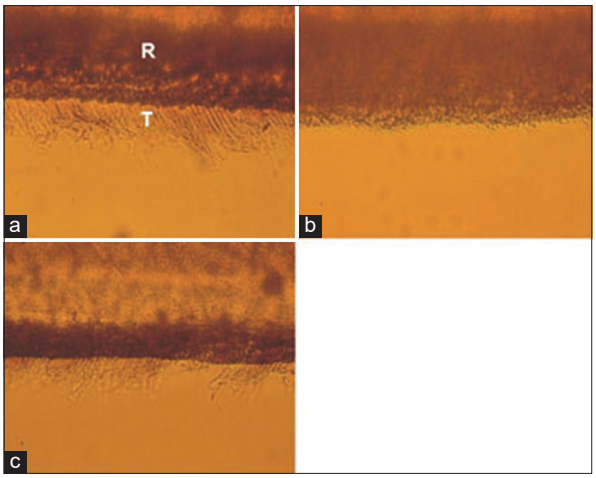

Figure 1: 30 longitudinal sections by wearing (100 mm) of the enamel-resin interface. (a) Photomicrograph of the interface of one specimen from the control group. (b) Interface achieved with application immediately after bleaching.(c) Interface achieved at 14 days after bleaching. R - resin; T - resin tags

and irregular tags in the groups restored immediately after completion of the bleaching treatment. Several hypotheses have been presented to explain this phenomenon; one of them mentions that bonding may be impaired by mineral, protein, and structural changes in the enamel.[19,21-23] However, this study revealed that penetration of the adhesive system into dental enamel was considerably increased at 7 days after bleaching. Thus, it may be suggested that the utilization of artificial saliva, which has a remineralizing potential, may have allowed the reorganization of the morphological changes occurring in the enamel,[21,24,25] thus allowing an etching pattern compatible with a good penetration of the adhesive system. According to Josey and colleagues in 1996, etching soon after bleaching with HP led to the loss of prismatic form, and the enamel seemed to be overetched. The accomplishment of restorative procedures immediately after completion of bleaching can considerably hamper the penetration of adhesive agents into the enamel surface, suggesting that a period of at least 7 days should be allowed between the utilization of peroxide bleaching material and restorative procedures that require acid etching and adhesive bonding materials. However, in view of the categorical results obtained.[22] It has been established that post in-office bleaching treatment with a whitening agent comprising 35% HP restorations in resin may be performed innocuously after 7 days when they involve the enamel structure and after 14 days when they involve the dentin structure. However, Perdigão *et al*.[19] found bleaching done with CP did not cause alterations in the relative concentration of oxygen present on the enamel surface, and suggested the oxygen remaining in dentin could be responsible for the reduction in bond strength after bleaching. For these reasons, they recommended immediate restoration with resin composite should be avoided after bleaching to allow time for the residual oxygen on the tooth surface to be eliminated. Spyrides *et al*.[13] suggested dentin could be more affected than enamel after HP-based dental bleaching due to its lower mineral content and the larger quantity of organic matrix.[26-33]

CONCLUSION

The bleaching treatment encourages patients to accept additional esthetic treatments. When patients have their teeth bleached, they often become interested in replacement of old restorations, closure of diastemas, or other esthetic procedures. In addition, bleaching may be indicated before placement of an esthetic resin restoration to obtain a more pleasing final shade for the case. However, it is suggested that a time interval of at least 7 days should be allowed between enamel bleaching and placement of adhesive bonding agents for accomplishment of resin-based restorations such as composites.

REFERENCES

1. Hattab FN, Qudeimat MA, Al-Rimawi HS. Dental discoloration: An overview. J Esthet Dent 1999;11:291-310.
2. Watts A, Addy M. Tooth discolouration and staining: A review of the literature. Br Dent J 2001;190:309-16.
3. Swift EJ Jr. Restorative considerations with vital tooth bleaching. J Am Dent Assoc 1997;128:60S-4S.
4. Kum KY, Lim KR, Lee CY, Park KH, Safavi KE, Fouad AF, *et al.* Effects of removing residual peroxide and other oxygen radicals on the shear bond strength and failure modes at resin-tooth interface after tooth bleaching. Am J Dent 2004;17:267-70.
5. Hallett KB, Garcia-Godoy F. Microleak-age of resin-modified glass ionomer cement restorations: An *in vitro* study. Dent Mater 1993;9:306-11.
6. Turkun M, Kaya AD. Effect of 10% sodium ascorbate on the shear bond strength of composite resin to bleached bovine enamel. J Oral Rehabil 2004;31:1184-91.
7. Attin T, Hannig C, Wiegand A, Attin R. Effect of bleaching on restorative materi- als and restorations-a systematic review. Dent Mater 2004;20:852-61.
8. Cavalli V, Giannini M, Carvalho RM. Effect of carbamide peroxide bleaching agents on tensile strength of human enamel. Dent Mater 2004;20:733-9.
9. Hegedüs C, Bistey T, Flora-Nagy E, Keszthelyi G, Jenei A. An atomic force microscopy study on the effect of bleaching agents on enamel surface. J Dent 1999;27:509-15.
10. Haywood VB. A comparison of at-home and in-office bleaching. Dent Today 2000;19:44.
11. Basting RT, Rodrigues AL, Serra MC. The effects of seven carbamide peroxide bleaching agents on enamel microhardness over time. J Am Dent Assoc 2003;134:1335- 42.
12. Miranda CB, Pagani C, Benetti AR, Matuda FS. Evaluation of bleached enamel by scanning electron microscopy. J Appl Oral Sci 2005;13:204-11.
13. Spyrides GM, Perdigão J, Pagani C, Araújo MA, Spyrides SM. Effect of whitening agents on dentin bonding. J Esthet Dent (Canada) 2000;12:264-70.
14. Ben-Amar A, Liberman R, Gorfil C, Bernstein Y. Effect of mouth guard bleaching on enamel surface. Am J Dent 1995;8:29-32.
15. Lewinstein I, Hirschfeld Z, Stabholz A, Rotstein I. Effect of hydrogen peroxide and sodium perborate on the micro hardness of human enamel and dentin. J Endod 1994;20:61- 3.
16. Zalkind M, Arwaz JR, Goldman A, Rotstein I. Surface morphology changes in human enamel, dentin and cementum following bleaching: A scanning electron microscopy study. Endod Dent Traumatol 1996;12:82-8.
17. Hegedüs C, Bistey T, Flora-Nagy E, Keszthelyi G, Jenei A. An atomic force microscopy study on the effect of bleaching agents on enamel surface. J Dent 1999;27:509-15.
18. McCracken MS, Haywood VB. Demineralization effects of 10 percent carbamide peroxide. J Dent 1996;24:395-8.
19. Perdigão J, Francci C, Swift EJ Jr. Ambrose WW, Lopes M. Ultra-morphological study of the interaction of dental adhesives with carbamide peroxide-bleached enamel. Am J Dent 1998;11:291-301.
20. Nikaido T, Kunzelmann KH, Ogata M, Harada N, Yamaguchi S, Cox CF, *et al*. The *in vitro* dentin bond strengths of two adhesive systems in class I cavities of human molars. J Adhes Dent 2002;4:31-9.
21. McEvoy SA. Chemical agents for removing intrinsic stains from vital teeth. II. Current techniques and their clinical application. Quintessence Int 1989;20:379-84.
22. Titley KC, Torneck CD, Smith DC, Abider A. Adhesion of composite resin to bleached and unbleached bovine enamel. J Dent Res 1988;67:1523-8.
23. Cvitko E, Denehy GE, Swift EJ Jr, Pires JA. Bond strength of composite resin to enamel bleached with carbamide peroxide. J Esthet Dent 1991;3:100-2.
24. Da Silva Machado J, Cândido MS, Sundfeld RH, De Alexandre RS, Cardoso JD, Sundefeld ML, *et al*. The influence of time interval between bleaching and enamel bonding. J Esthet Restor Dent 2007;19:111-8.
25. Osey AL, Meyers IA, Romaniuk K, Symons AL. The effect of a vital bleaching technique on enamel surface morphology and the bonding of composite resin to enamel. J Oral Rehabil 1996;23:244-50.

26. Lai SC, Tay FR, Cheung GS, Mak YF, Carbalho RM, Wei SH, *et al*. Reversal of compromised bonding in bleached enamel. J Dent Res 2002;81:477-81.
27. Dishman MV, Covey DA, Baughan LW. The effects of peroxide bleaching on composite to enamel bond strength. Dent Mater 1994;10:33-6.
28. Garcia-Godoy F, Dodge WW, Donohue M, Quinn JA. Composite resin bond strength after enamel bleaching. Oper Dent 1993;18:144-7.
29. Haywood VB, Heymann HO. Night guard vital bleaching. Quintessence Int 1989;20:173-6.
30. Sundfeld RH, Briso AL, De Sá PM, Sundfeld ML, Bedran-Russo AK. Effect of time interval between bleaching and bonding on tag formation. Bull Tokyo Dent Coll 2005;46:1-6.
31. McCracken MS, Haywood VB. Demineralization effects of 10 percent carbamide peroxide. J Dent 1996;24:395-8.
32. Rueggeberg FA, Hashinger DT, Fairhurst CW. Calibration of FTIR conversion analysis of contemporary dental resin composites. Dent Mater 1990;6:241-9.
33. Claire J, Williams PT. Shear strengths of a gallium alloy bonded to human enamel following nine different surface treatments. Dent Mater 2001;17:116-21.

How to cite this Article: Vijan K. Mechanism of action and clinical effects of teeth whitening on enamel and dentin bonding for resin-based restorations. Asian Pac. J. Health Sci., 2018; 5(1):142-145.

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