View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Elsevier - Publisher Connector

The Saudi Journal for Dental Research (2015) 6, 124–128

King Saud University

The Saudi Journal for Dental Research

www.ksu.edu.sa
www.sciencedirect.com

ORIGINAL ARTICLE

Effects of different bleaching agent concentrations on surface roughness and microhardness of esthetic restorative materials

Salma A. Bahannan *

Oral and Maxillofacial Prosthodontics Department, Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia

Received 15 September 2014; revised 7 January 2015; accepted 23 January 2015
Available online 10 February 2015

KEYWORDS

Bleaching;
Concentrations;
Esthetic;
Composite;
Glass ionomer;
Porcelain

Abstract *Objectives:* The study assessed the changes in surface roughness and microhardness of three esthetic restorative materials after bleaching with 10%, 20% and 35% carbamide peroxide (CP).

Methods: Standardized cylindrical specimens (n = 210) of 3 esthetic materials (nano composite resin (NC), resin modified glass ionomer (GI), feldspathic porcelain (FP) were fabricated (n = 70). They were divided into 3 groups (n = 20) and a control group (n = 10). Each group was bleached with different concentrations of CP. The specimens of group 1 and 2 (10% CP and 20% CP) were immersed in the bleaching gels for 6 h daily, while group 3 (35% CP) was immersed for 30 min weekly. The control group was stored in artificial saliva. After 21 days, the morphological changes of the specimens were investigated with surface texture analyzer, while the hardness was assessed by performing superficial microhardness analysis. The data were analyzed with one-way ANOVA, and Scheffe test at $\alpha = 0.05$.

Results: No significant differences in roughness average (Ra) were recorded among the control group and 10% CP bleached groups of all tested restorative materials (NC ($p = 0.1495$), GI ($p = 0.0761$), FP ($p = 0.2848$)). However, there were significant differences in Ra among the control group, 20% CP, and 35% CP ($p < 0.05$). There were no significant differences in the microhardness of feldspathic porcelain (10% ($p = 0.0786$), 20% ($p = 0.1041$), and 35% ($p = 0.2066$). While nano composite resin and resin modified glass ionomer specimens were significantly affected by concentration of 20% and 35% CP ($p < 0.05$).

* Address: PO Box 10390, Jeddah 21433, Saudi Arabia. Tel.: +966 504695411.
E-mail address: sbahannan@kau.edu.sa.

Peer review under responsibility of King Saud University.

ELSEVIER Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.sjdr.2015.01.002

2352-0035 © 2015 The Author. Production and hosting by Elsevier B.V. on behalf of King Saud University.
This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Conclusion: The effect of bleaching depends on the concentration of CP. The higher surface roughness was produced by 35% CP. Bleaching with different concentrations did not reduce the microhardness of the feldspathic porcelain. However, microhardness of nano composite resin and resin modified glass ionomer specimens was affected by 20% CP and 35% CP.

© 2015 The Author. Production and hosting by Elsevier B.V. on behalf of King Saud University. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

1. Introduction

The achievement of optimal esthetic restorations is the most stressful procedure that is concerned by dentists.[1] Although esthetics can be improved using a variety of techniques, bleaching is considered a safe, conservative, low cost and effective esthetic procedure for treatment of discolored teeth.[2,3] Numerous bleaching agents have been marketed but the commonly used active ingredient is carbamide peroxide (CP).[4]

Researchers[5,6] have reported that proper bleaching depends on the bleaching time, concentration of active bleaching ingredient, type and intensity of stain. Bleaching process includes oxidation which causes chemical modification of the discolored molecules.[7] CP bleaching gels (10% and 16%) may cause a significant increase in the surface roughness of microfilled and hybrid composite resins.[8] However, there is controversy about the effect of low concentrated 10–16% carbamide peroxide gels on surface microhardness of composite materials. Turker and Biskin found application of home-bleaching gels caused softening of composite resins.[9] However others reported that application of home-bleaching gels increased the surface hardness.[8,10]

It has been reported that when highly concentrated bleaching agents were applied for 5 days, they induced surface degradation, softening of modified composite resin,[11] while three bleaching sessions of 30 min for one week intervals did not affect the surface finish of compomers, resin-modified glass ionomer cements or glass ionomer cements.[12] Cehreli et al. claimed that after treatment with 10–16% CP bleaching gels, increased surface roughness of some brands of those materials were noted, while other gels had decreased surface roughness.[13] They concluded that the effects of the gels seem to be material dependent.[13]

Conventional dental ceramics are inert dental restorative materials, and acidulated fluoride gels or other solutions can result in ceramic surface deterioration.[14] Turker and Biskin[8,10] observed that 10% CP and 16% CP gels were able to significantly decrease surface hardness of the porcelain material tested. It was also reported that surface roughness may result in more plaque accumulation or change the ceramic texture if exceeds 0.2 μm.[15] Few literature addressed the possible alteration of the surface properties of esthetic restorative materials at different concentrations of carbamide peroxide.[8,10–14,16,17]

The null hypothesis of the current study was that the surface roughness and the microhardness of the selected materials would not be affected by different concentrations of carbamide peroxide of the bleaching agents. The purpose of the study was to evaluate the effect of different concentrations of carbamide peroxide on the surface roughness and microhardness of the esthetic restorative materials.

2. Material and methods

Three different esthetic restorative materials (nano composite resin, resin modified glass ionomer, feldspathic porcelain) of shade A2 (Vita shade guide, Vita Zahnfabrik, Germany) were used (Table 1). Three carbamide peroxide (CP) bleaching products were selected (Table 2). Two at-home bleaching system (10% and 20% CP) (Opalescence, Ultradent, USA), and one in-office system (35% CP) (Opalescence, Ultradent, USA).

2.1. Preparation of specimens

Seventy cylindrical specimens were prepared for each type of the tested restorative material. All materials were prepared according to the manufacturers' instructions. The control group (n = 10) was stored in Fusayama artificial saliva[18] (KCl (0.4 g/l), NaCl (0.4 g/l), $CaCl_2$ (0.6 g/l), NaH_2PO_4 (0.690 g/l), and urea (1 g/l) for 21 days). The other test specimens (n = 60) were divided into three groups (n = 20 in each group) according to different bleaching agents (10%, 20%, and 35% CP).

2.2. Composite resin and resin modified glass ionomer

Campos et al.[11] mold was prepared; 4×2 mm cylindrical acrylic matrixes were fabricated. They were filled with the restorative material. Composite resin or glass ionomer material was placed incrementally. A polyester strip and glass slide was then placed over it with a constant pressure of a weight of 500 g for 30 s. The specimens were cured for 20 s by a LED curing light system (Lume LED 5, Ultradent Products Inc., South Jordan, UT, USA). The light intensity was 650 mW/cm^2. The light tip was 1mm away from the specimen. The specimens were then polished (Sof-Lex, 3M ESPE, USA), and stored in distilled water at 37 °C for 24 h.

2.3. Feldspathic porcelain

A stainless steel mold consisting of two plates was prepared.[7] It had 4 holes which were 10 mm in diameter. The metal mold was duplicated and porcelain specimens were prepared similar to Turker et al. technique.[7]

2.4. Bleaching process

The specimens were placed in a plastic box and immersed in the bleaching gel. The first and second group (10% and 20% CP) were left for 6 h daily. The third group (35% CP) was left for 30 min weekly. All specimens were washed with distilled water then kept immersed in Fusayama artificial saliva at

Table 1 Tested esthetic restorative materials.

Product	Manufacturer	Type	Code	Composition
Filtek Supreme	3M ESPE, St Paul, MN, USA	Nanofilled composite resin	NC	bisGMA, UDMA,TEGDMA, bisEMA, Procrylat resins, Zirconia/Silica
Fuji II LC	GC Corp, Tokyo, Japan	Resin-modified glass ionomer cement	GI	Fluoroaluminosilicate glass, Polycyclic acid, Polyacrylic acid, HEMA
Duceram	Ducera Dental GmbH, Rosbach, Germany	Feldspathic porcelain	FP	K_2O_2, Al_2O_3, SiO_2, SnO, ZrO, Na_2O, CaO, pigments

Table 2 Bleaching agents of the study.

Product	Manufacturer	pH	Composition
Opalescence	Ultradent Products Inc., South Jordan, UT, USA	6.68	10% carbamide peroxide, carbopol, glycerin, flavoring
Opalescence	Ultradent Products Inc., South Jordan, UT, USA	6.71	20% carbamide peroxide, carbopol, glycerin, flavoring
Opalescence	Ultradent Products Inc., South Jordan, UT, USA	6.73	35% carbamide peroxide carbopol, glycerin, flavoring

37 °C until the next application. The bleaching procedure was performed for 21 days.

2.5. Surface roughness measurements

Prior to the bleaching process, base-line surface roughness measurements were conducted using surface profilometer with 0.25 mm cut off (λc) at 0.1 mm/s. (Surfanalyzer 4000, Federal Products Corp, USA). Roughness average was recorded. However, other parameters (root mean square, maximal peak-to-valley height, and low-point height) were also used to properly specify the surface finish. On each specimen surface, three parallel measurements in a longitudinal direction were marked and averaged.

2.6. Hardness test

All specimens were analyzed in a microhardness tester (LeitztMiniload2, Ernst Leitzt GmbH, Germany). The Knoop hardness measurement was recorded in five places. A load of 300 g was applied on the porcelain specimens, and 50 g load on the composite and resin modified glass ionomer specimens with a magnification of 500×.[8] The loading time was 30 s for all groups. Then the average of the values was calculated.

2.7. Statistical analysis

Data were analyzed using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). One-way analysis of variance (ANOVA) was used for comparison among groups and Scheffe test at $\alpha = 0.05$ was used for multiple comparison among means.

3. Results

A statistically significant difference in roughness parameters was found among different concentrations of bleaching agent ($P < .001$). The roughness parameter magnitude depends on the restorative material. Table 3 and Fig. 1 present the surface roughness mean values (μm) of all tested groups. In all restorative materials, there were no significant differences in roughness values among the control and 10% CP groups (Filtek Supreme: $p = 0.1495$; Fuji II LC: $p = 0.0761$; Duceram: $p = 0.2848$). However, exposure to 20% CP and 35% CP groups caused a significant increase in roughness after 21 days for all restorative materials ($p < 0.05$).

Table 3 Roughness mean (μm) and standard deviation of tested materials.

Material	Roughness mean (μm) and standard deviation	*P* value
Filtek Supreme		
Control	0.05 ± 0.01	
10% CP	0.06 ± 0.02	0.1495
20% CP	0.07 ± 0.02	0.0061
35% CP	0.19 ± 0.07	0.0001
Fuji II LC		
Control	0.06 ± 0.02	
10% CP	0.07 ± 0.01	0.0761
20% CP	0.09 ± 0.01	0.0001
35% CP	0.20 ± 0.02	0.0001
Duceram		
Control	0.08 ± 0.03	
10% CP	0.09 ± 0.02	0.2848
20% CP	0.11 ± 0.03	0.0153
35% CP	0.19 ± 0.03	0.0001

Table 4 and Fig. 2 show the mean Knoop hardness values (KHN) of the tested groups. According to multiple comparison among mean values, bleaching with different CP concentrations did not produce any statistically significant effect on the micro-hardness of Duceram ($p = 0.2066$). However, there is a significant difference by concentration (20% and 35% CP) in the mean hardness for Filtek Supreme and Fuji II LC ($p < 0.05$).

4. Discussion

Although there is widespread use of bleaching agents, there is no agreement on the effect of bleaching agents on the restorative materials.[2] The physical alteration of tooth-colored

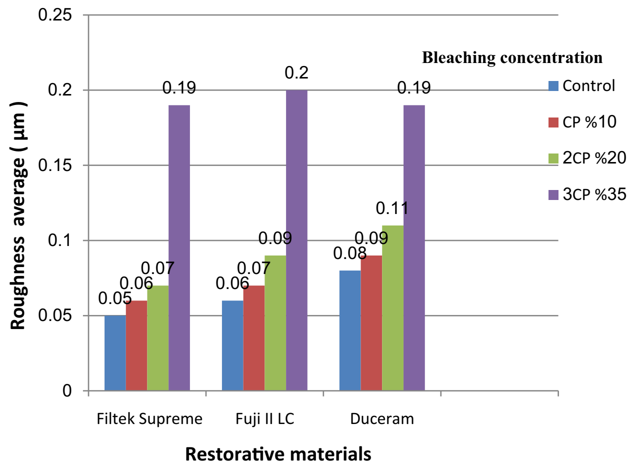

Figure 1 Roughness mean (µm) of the tested materials.

Table 4 Hardness mean and standard deviation (KHN) of tested materials.

Material	Hardness mean and standard deviation	*P* value
Filtek Supreme		
Control	45.9 ± 1.3	
10% CP	44.8 ± 6.2	0.5860
20% CP	42.9 ± 4.4	0.0458
35% CP	40.3 ± 3.1	0.0001
Fuji II LC		
Control	47.5 ± 3.3	
10% CP	44.2 ± 4.6	0.0535
20% CP	41.1 ± 1.7	0.0001
35% CP	40.7 ± 6.8	0.0060
Duceram		
Control	193.9 ± 32.9	
10% CP	191.2 ± 21.1	0.07865
20% CP	177.2 ± 21.4	0.1041
35% CP	176.6 ± 35.3	0.2066

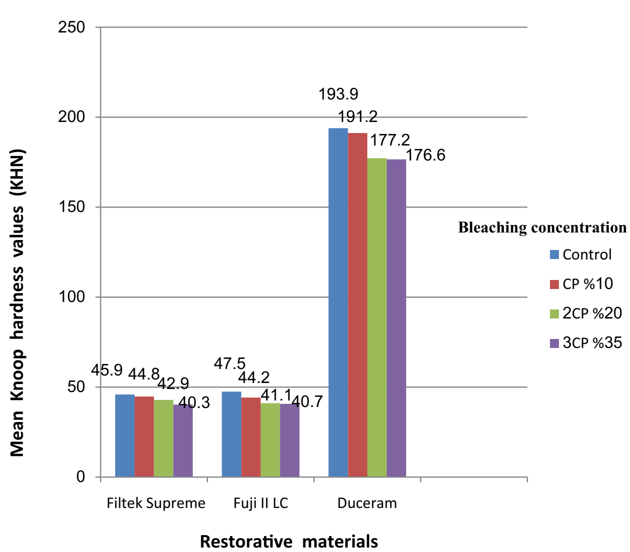

Figure 2 Mean Knoop hardness values (KHN) of tested materials.

restorative materials is an important consideration when bleaching is performed. Restorative materials tested must withstand degradation in the presence of different chemicals with variable pH levels.[15] In the present study, two at–home bleaching materials (Opalescence, 10% CP and 20% CP) and an in-office bleaching material (Opalescence, 35% CP) were used.

The hypothesis of the current study was rejected, since the bleaching systems with 20% CP and 35% CP have affected the tested restorative materials. It significantly increased the roughness after 21 days for all restorative materials (Table 3). The mechanism of how bleaching regimens affect restorative material is not clear, but presumably this may be due to break down of CP into hydrogen peroxide and urea in aqueous solution, with hydrogen peroxide being the active bleaching agent, which may penetrate the surface of restorative materials.[19] No significant differences in roughness were observed after bleaching with 10% CP comparing with 20% CP and 35% CP. It was claimed that the difference between at-home and in-office bleaching on tooth colored restorative materials related to the action of active bleaching agent.[20] Wattanapayungkul et al. reported that treating composite resins with a low peroxide concentration (10% and 15% carbamide peroxide) significantly increased their surface roughness after 8 weeks.[21] They claimed that repolishing or replacement of tooth-colored restorations may be required after bleaching procedures.[21]

The results of the current study support those of Zavanelli et al.[18] who reported that no alterations were observed on ceramic surfaces treated with 10% or 15% carbamide peroxide for 21 days. Although optimal bleaching time was not defined and may be extended to longer treatment periods in patients with severe discoloration, 21 day bleaching was done to simulate the night guard bleaching treatment, as most patients achieve the best results within this period.[17] In a published review,[22] it was stated that 35% CP affected the surface roughness of dental ceramics. Moraes and his colleagues[23] who evaluated the effect of high peroxide concentrations (35%) came to a similar conclusion. Since exposing those restorative materials to such chemicals exhibits increased roughness, therefore, bleaching with high concentration should be done carefully and should be avoided on the restorations.

It is known that hardness is related to a materials' strength, proportional limit, and its ability to abrade or to be abraded by opposing dental structures' materials.[15] Therefore any chemical softening resulting from bleaching might have implications on the durability of restorations. In the current study, no surface microhardness changes were observed in all tested 10% CP groups. Turker et al. also[8,10] reported that using 10% CP or 16% CP did not affect the microhardness of the restorative materials.

On the other hand, we found that the microhardness of nano composite resin and resin modified glass ionomer were reduced significantly with 20% and 35% CP. Our results in contrast with the results of others.[4,24,25] They claimed that no significant difference was observed in tested composite materials when bleached with the highest concentrations. The variations in data could be due to the susceptibility of some tooth colored restorative materials and the difference in pH values among the bleaching agents.[24] Regarding the microhardness of resin-modified glass ionomer, Taher noticed an average decrease in surface hardness for both at-home and in-office groups (15% CP, 35% HP) after 15 days.[26] The decrease of surface hardness of modified glass ionomer was referred to the porosities and filler particle.

In the present study, there was no statistical significant difference in the microhardness of ceramic specimens. Polydoroua et al.[25] found that 38% hydrogen peroxide did not affect the microhardness of ceramic restorations 30 days after the end of bleaching, in contrast with the findings of others[8,10] who found that 10–16% CP applied for 8 h daily were able to significantly decrease surface hardness of feldspathic porcelain material.

One of the limitations of this study is that volume loss from the restorative material surface was not estimated. The other limitation is that an energy-dispersive X-ray microanalysis of ceramic surfaces was not determined. Furthermore, only one type of composite, resin-modified glass ionomer, and ceramic were tested.

5. Conclusion

Within the limitation of this study, the following conclusions can be withdrawn:

1. The impact of bleaching agents on surface roughness could be considered concentration dependent.
2. The surface roughness of tested restorative materials increased with 20% and 35% CP.
3. The microhardness of feldspathic was not affected by different concentrations of CP.
4. The microhardness of nano composite resin and resin modified glass ionomer were reduced significantly with 20% and 35% CP.

Conflict of interest

No conflict of interest is declared for this work.

Acknowledgements

The author thanks King Abdulaziz City for Science and Technology, Riyadh, Saudi Arabia, for supplying the grant No. AT – 30 – 311. She also thanks Prof. Mohamed Ayad for his valuable assistance, and Prof. Mona Alhassan for her assistance in the statistical analysis.

References

1. Sadowsky SJ. An overview of treatment considerations for esthetic restorations: a review of the literature. *J Prosthet Dent* 2006;**96**:433–42.
2. Meireles S, Fontes ST, Coimbra LA, Della Bona A, Demarco FF. Effectiveness of different carbamide peroxide concentrations used for tooth bleaching: an *in vitro* study. *J Appl Oral Sci* 2012;**20**:186–91.
3. Demarco FF, Meireles SS, Masotti AS. Over-the-counter whitening agents: a concise review. *Braz Oral Res* 2009;**23**:64–70.
4. Alaghehmand H, Esmaeili B, Sheibani SA. Effect of fluoride-free and fluoridated carbamide peroxide gels on the hardness and surface roughness of aesthetic restorative materials. *Indian J Dent Res* 2013;**24**:478–83.
5. Ertas E, Guler AU, Yucel AC, Köprülü H, Guler E. Color stability of resin composites after immersed in different drinks. *Dent Mater* 2006;**25**:371–6.
6. Meireles SS, Heckmann SS, Leida FL, dos Santos Ida S, Della Bona A, Demarco FF. Efficacy and safety of 10% and 16% carbamide peroxide tooth-whitening gels: a randomized clinical trial. *Oper Dent* 2008;**33**:606–12 Nov–Dec.
7. Matis BA, Yousef M, Cochran MA, Eckert GJ. Degradation of bleaching gels in vivo as a function of tray design and carbamide peroxide concentration. *Oper Dent* 2002;**27**:12–8.
8. Turker SB, Biskin T. Effect of three bleaching agents on the surface properties of three different esthetic restorative materials. *J Prosthet Dent* 2003;**89**:466–73.
9. Ourique SA, Arrais CA, Cassoni A, Ota-Tsuzuki C, Rodrigues JA. Effects of different concentrations of carbamide peroxide and bleaching periods on the roughness of dental ceramics. *Braz Oral Res* 2011;**25**:453–8.
10. Turker SB, Biskin T. The effect of bleaching agents on the microhardness of dental aesthetic restorative materials. *J Oral Rehabil* 2002;**29**:657–61.
11. Campos I, Briso AL, Pimenta LA, Ambrosano G. Effects of bleaching with carbamide peroxide gels on microhardness of restoration materials. *J Esthet Restor Dent* 2003;**15**:175–82.
12. Lee JH, Kim HI, Kim KH, Kwon YH. Effect of bleaching agents on the fluoride release and microhardness of dental materials. *J Biomed Mater Res* 2002;**63**:535–41.
13. Cehreli ZC, Yazici R, Garcia-Godoy F. Effect of home-use bleaching gels on fluoride releasing restorative materials. *Oper Dent* 2003;**28**:605–9.
14. Wattanapayungkul P, Yap AUJ. Effects of in-office bleaching products on surface finish of tooth-colored restorations. *Oper Dent* 2003;**28**:15–9.
15. Anusavice KJ. Degradability of dental ceramics. *Adv Dent Res* 1992;**6**:82–9.
16. Zaki AA, Fahmy NZ. The effect of a bleaching system on properties related to different ceramic surface textures. *J Prosthodont* 2009;**18**:223–9.
17. Leonard Jr RH, Bentley C, Eagle JC, Garland GE, Knight MC, Phillips C. Nightguard vital bleaching: a long-term study on efficacy, shade retention. side effects, and patients' perceptions. *J Esthet Restor Dent* 2001;**13**:357–69.
18. Zavanelli AC, Mazaro VQ, Silva CR, Zavanelli RA, Mancuso DN. Surface roughness analysis of four restorative materials exposed to 10% and 15% carbamide peroxide. *Int J Prosthodont* 2011;**24**(2):155–7.
19. Bailey SJ, Swift Jr EJ. Effects of home bleaching products on composite resins. *Quintessence Int* 1992;**23**:489–94.
20. Ernst CP, Marroquín BB, Willershausen-Zönnchen B. Effects of hydrogen peroxide-containing bleaching agents on the morphology of human enamel. *Quintessence Int* 1996;**27**(1):53–6.
21. Wattanapayungkul P, Yap AUJ, Chooi KW, Lee MFLA, Selamat RD, Zhou RD. The effect of home bleaching agents on the surface roughness of tooth-colored restoratives with time. *Oper Dent* 2004;**29**:398–403.
22. El-Murr J, Ruel D, St-Georges AJ. Effects of external bleaching on restorative materials: a review. *J Can Dent Assoc* 2011;**77**:b59.
23. Moraes RR, Marimon JL, Schneider LF, Correr Sobrinho L, Camacho GB, Bueno M. Carbamide peroxide bleaching agents: effects on surface roughness of enamel, composite and porcelain. *Clin Oral Investig* 2006;**10**(1):23–8 Epub 2005 Nov 16.
24. Yap AU, Wattanapayungkul P. Effects of in-office tooth whiteners on hardness of tooth-colored restoratives. *Oper Dent* 2002;**27**:137–41.
25. Polydoroua O, Montingb JS, Hellwiga E, Auschill TM. Effect of in-office tooth bleaching on the microhardness of six dental esthetic restorative materials. *Dent Mater* 2007;**23**:153–8.
26. Taher NM. The effect of bleaching agents on the surface hardness of tooth colored restorative materials. *J Contemp Dent Pract* 2005;**6**(18):26.