

The effect of different bleaching materials on the solubility of enamel

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Abstract

In this research, the effect of three bleaching materials, 20% carbamide peroxide, 35% carbamide peroxide and 38% hydrogen peroxide on the solubility of enamel is examined. For this study, 30 premolar teeth extracted for orthodontic purpose were used. They were divided into three groups 10 teeth in each. Crowns of the teeth were divided into 2 pieces longitudinally. One part of the tooth crown was used as control and the other part was used as experimental group. 20 percent carbamide peroxide was applied at 37^o C during 6 hours for 8 days to the first test group (at-home bleaching), 35 percent carbamide peroxide was applied at 37^o C for 30 minutes for 8 days to the second test group (at-home bleaching) and 38 percent hydrogen peroxide was used 4 times for 15 minutes making a total 60 minutes on the remaining ten specimen (in-office bleaching). The solubility of the enamel was calculated by the determination of inorganic phosphorus using a spectrophotometer. Comparative analysis of the depths in the groups was carried out and its relation with mineral loss was evaluated. Paired t-test was used to compare the differences between the groups. A statistically significant difference was found between the control and the study groups for the 38% hydrogen peroxide. There was no statistically significant difference between the control and experimental groups in the other two groups. It is concluded that of these three bleaching materials, 38% hydrogen peroxide has the greatest effect on mineral loss from the enamel.

Keywords: Bleaching, carbamide peroxide, hydrogen peroxide

Introduction

In recent years, people are choosing more esthetics solutions to their dental treatment. Most people assume white teeth as aesthetic teeth [1]. For this reason tooth bleaching is gaining a great interest between people. People of the modern age are aware of the teeth's importance on physical aesthetic. So, they are deeply interested in the methods of teeth bleaching [2].

Chappell firstly advised the bleaching system in 1877 [3]. Bleaching technique's main rule depends on disintegration of the components that give their own color by oxidation. Tooth bleaching methods may be sorted out as at-home or in-office applications [3,4].

First method is putting, the bleaching material in a soft plate which is prepared via the dental impression. After using 7-15 days, the best whiteness creation is obtained. It's advised to use it 2-8 hours -a day during the sleeping time. It's advised to use it 2-8 hours - a day during the sleeping time. 20-35 percent concentration of carbamide peroxide is the most common material in this system [5].

The second method is In-office bleaching. In this method, the bleaching material is applied by the dentist. Despite the fact that a number of bleaching agents have been recommended, hydrogen peroxide still continues to be the most frequently used agent [6]. This material can be polymerized by light or in chemical way. 15% - 38% hydrogen peroxide is the most common material in this system [1,7,8].

The bleaching systems have good aesthetical results. Although they have some side effects such as: irritations on the mucous membrane of the oral cavity, fractures, differences on composite restorations, post-operative sensitivities, anatomical changes on the enamel [9]. For that reason, it is essential to be aware of the possible complications and risks that are related with the different bleaching methods [8].

Despite the common use of bleaching materials, the present knowledge of possible unfavorable sequela is still doubtful. So, the purpose of our study was to determine the effect of at-home (20% - 35% carbamide peroxide) and in-office (38% hydrogen peroxide) bleaching materials on the solubility of enamel surfaces.

For the present study, the null hypothesis assumes that there is no difference in the solubility of enamel surfaces of different bleaching materials.

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Materials and Method

The preparation the enamel surface for research

30 non carious maxillary first premolar teeth extracted for orthodontic purpose were used. They were divided into three groups as 10 teeth in each group. Crowns of the teeth were divided into 2 pieces longitudinally using millimeter ruler. The one part of the tooth crown was used as control and the other part was used as experimental group. Surfaces of the dentin and cement were covered by the colorless nail polish. All of the teeth were placed in artificial saliva for 24 hours. The teeth were washed by distilled water for 15 seconds and they were dried by blotting paper (denstply).

Application of the bleaching materials to the enamel

In-Home Bleaching protocol

20% carbamide peroxide application (Opalescence PF take-home bleaching, Ultradent Products): Bleaching agents were applied to the surface. Teeth were placed for 6 hours at 37 °C in a day according to the manufacturer's directions (chemical activated). After they were washed out by distilled water for 15 seconds and they were dried by blotting paper.

35% carbamide peroxide application (Opalescence PF In-home bleaching, Ultradent Products): Bleaching agents were applied to the surface. Teeth were placed for 30 minutes at 37 °C in a day according to the manufacturer's

directions (chemical activated). After the teeth washed out by distilled water for 15 second and they were dried by blotting paper.

The teeth bleached with 20% and 35% carbamide peroxide were placed in artificial saliva in incubator at 37°C until the next day application to simulate the oral tissue. The process was repeated for 8 days in the experiment groups at the same time according to the manufacturer's directions.

In-Office Bleaching protocol

38% hydrogen peroxide application (Opalescence Xtra Boost In-office bleaching, Ultradent Products). Bleaching agents were applied to surface. The teeth were bleached with 38% hydrogen peroxide for 15 minutes, 4 times by a spatula (chemical activated). They were applied for a total of 60 minutes. Then they were washed out by distilled water for 15 seconds and they were dried by blotting paper. And 0.11 ppm fluoride applied for 60 minutes according to the manufacturer's directions.

They were prepared for stickers. The control groups were placed in artificial saliva in an incubator at 37°C during the research.

All the agents and the application protocols were shown in Table I.

Table 1. Bleaching Techniques, Commercial name, Manufacturer/Distributor, Activation system, Main composition and Application procedure of the Agents Used in the Study

Bleaching Techniques	Commercial name	Manufacturer/ Distributor	Activation system	Main composition	Application procedure
Home-use bleaching technique	Opalescence PF 20%	Ultradent Products, South Jordan UT, USA	Chemical activation	20% carbamide peroxide	6 hours in a day; for 8 days
	Opalescence PF 35%	Ultradent Products, South Jordan UT, USA	Chemical activation	35% carbamide peroxide	30 minutes in a day; for 8 days
In-office bleaching technique	Opalescence Xtra Boost 38%	Ultradent Products, South Jordan UT, USA	Chemical activation	38% hydrogen peroxide	15 minutes, 4 times; only one day

Preparation of the control groups

The all control (one part of the tooth crown) groups were placed in artificial saliva in an incubator at 37°C during the research to simulate the oral tissue.

The preparation of enamel surfaces for the experiment

Stickers (Crea ticket, Ofix) are used to create a specific and milimetric test area. Stickers with a radius of 1.05 mm were placed on the enamel and cement surfaces 1 mm away from the crown-root border. The rest of surface was covered by the colorless nail polish. After nail polish was dried, the stickers were taken outliving 3.46 mm² enamel surface uncovered.

The resolution experiment of the enamel surfaces

Chemical analyses were performed in the Biochemistry Laboratory of Faculty of Dentistry, Istanbul University.

Experiment and control groups teeth were dipped into 1.00 ml 0.5 M HClO₄ by cotton player by nail polish and they were shaken up in a small beats for 30 second. The surface solubility was evaluated by determination of inorganic phosphorus in biopsy samples. UV-1601 VISIBLE spectrophotometer was used for measurements and the results were expressed as % mg Pi.

Calculating of solute enamel depth

mass= volume x density (m = v x d)

d = 2,95 g/ cm³

the area = 0,0346 cm²

It is known that 17% of enamel mass is composed of phosphorus, so enamel mass in grams was;

m= mgP x 0,17 enamel

porous depth of enamel = $\frac{\text{mgP} \times 0,17}{0,0346\text{cm}^2 \times 2,95 \text{g/cm}^3}$

The statistical analysis

Paired t-test was used to compare the difference between the experiment and controls in each group. Also groups were compared for difference of Experiment and Control with Analysis of Covariance. IBM SPSS Statistics ver. 20 was used for the analyses. When the *p*-value was less than 0.05, the statistical test was determined as significant.

Results

There was no significant difference between the controls and tests in the 20% carbamide peroxide group on the solubility of enamel. Similarly, no significant difference

was found between the control and test groups for the 35% carbamide peroxide on the solubility of enamel (Table II). Consequently, 20% carbamide peroxide and 35% carbamide peroxide (at-home bleaching) does not have any hazardous effect on the solubility of enamel surfaces.

Significant difference was found between the control and test groups for the 38% hydrogen peroxide on the solubility of enamel ($t=4.55$ $p=0.001$) (Table II). When 38% hydrogen peroxide (in-office bleaching) is used the surfaces of enamel was effected which was shown by increased enamel's solubility.

Table II. Descriptives values of solute enamel depth and multiple comparisons of the groups

Groups	Experimental and Control Groups	N	Mean	SD	Experimental– Control differences	t values	Sig.
Group 1	20% carbamide peroxide Experimental Group	10	7,21	0,65	-0,65^a	1,37	0,2
	20% carbamide peroxide Control Group	10	7,87	1,26			
Group 2	35% carbamide peroxide Experimental Group	10	11,99	2,33	1,52 ^b	1,22	0,25
	35% carbamide peroxide Control Group	10	10,48	2,72			
Group 3	38% hydrogen peroxide Experimental Group	10	12,39	3,53	5,38 ^b	4,55	0
	38% hydrogen peroxide Control Group	10	7,01	0,84			

N indicates: sample size; SD: standard deviation; Sig.: significance; Ancova for differences (Controls as covariates): $F=19.79$ $p<0.001$ for the control . $F=13.5$ $p<0.001$ for the differences. Bonferroni post-hoc tests: $p=0.001$ group 1 vs 2 ; $p<0.001$ group 1 vs 3 and $p>0.05$ group 2 vs 3

The difference between solubility in experimental and control groups treated with 20% carbamide peroxide agents (-0.65) differ from the difference between solubility in experimental and control groups treated with 35% carbamide peroxide (1.52) and 38% hydrogen peroxide groups (5.38). In other words, 20% carbamide peroxide supported bleached teeth enamel's remineralization.

Discussion

The particular the reduction of enamel solubility when using bleaching materials is important goal for dentists [5]. This unfavorable effect of bleaching on the enamel mineral (ions) expressed by many studies may be due to the concentration or category of the bleaching agent applied. Many research showed that demineralization (loss of mineral) causes a decrease in enamel micro hardness after bleaching treatment with high concentration of hydrogen peroxide [10]. So, the purpose of our study was to define the effect of bleaching materials in-home bleaching 20% - 35% carbamide peroxide and the in-office bleaching 38% hydrogen peroxide on the solubility of enamel surfaces.

Tooth enamel is the most intensive mineralized body tissue as minerals make up 96% of the enamel. The major mineral component is hydroxyapatite, with the essential formula of $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$, though other ions, such as fluoride are generally incorporated. The organic section of enamel does not contain collagen, as dentin and bone do. In its place, it has two unique classes of proteins called enamelin and amelogenin. The function of these proteins is not understood, but is probably involved in the improvement and the

structural integrity of enamel. The dissolution of the enamel in an acid happens as an effect of the interaction of hydroxyapatite and hydrogen ions. Measurement of the phosphate group in hydroxyapatite is thus a high quality indicator of the amount of mineralization of the enamel [9].

Bleaching systems that perform by means of strong oxidizers are frequently used for bleaching of teeth. Depending on the form of use, the concentrations lie between 10-35% peroxide. Especially, 35% concentrated carbamide peroxide or hydrogen peroxide is used [11]. The action method is based on oxidative discoloration of incorporated colorants. On the other hand, strong oxidizers as well degrade structure-relevant in the enamel [12]. The most accepted technique for the in-office bleaching of vital teeth contains 35% hydrogen peroxide, with phosphoric acid to facilitate bleaching.

Carbamide peroxide breaks down to obtain 3.6% hydrogen peroxide and urea, which in turn breaks down obtaining water, carbon dioxide, oxygen and ammonia and that outcome in a associated small lowering of pH of the bleaching materials. This decreasing in pH would affect the dissolution of the mineral content of enamel, though it is of interest to note that in vivo, 10% carbamide peroxide solution caused a pH increase above 7, which would not affect breakdown of enamel [9]. The high concentration of carbamide peroxide (35-37%) is designated as pretreatment and in relationship with at-home bleaching. These procedures are for professional use only, although about 11% of hydrogen peroxide is obtained after the peroxide degradation [10]. Bleaching consequences in the loss of phosphate groups from

surface enamel perhaps accompanied by enamel matrix degradation. If possible, bleaching materials should not be sustained to a point where surface enamel is lost, and the present research suggests to this means that the regime with 10% carbamide peroxide should not made longer than 7 days, particularly in patients whose salivary composition limits remineralization [9]. Most of the earlier researches, focused on enamel surface changes, demonstrate no significant effect of 10% carbamide peroxide on the enamel surface [5,13,14]. Most of them intend to use the different concentrate of carbamide peroxide at-home. Aroujo et al. [15] investigated the effect of two at-home bleaching materials on the microhardness of enamel surfaces treated with 10% carbamide peroxide. Using 10% carbamide peroxide (at-home bleaching) does not affect the solubility of enamel surfaces when compared with standards of the control nontreated materials. McCracken and Haywood [16] noticed that the amount of calcium loss from enamel surface exposed to a cola-based drink for 2.5 min, equal to the consumption of about 47 mL of that drink, is similar to that when applied 10% carbamide peroxide bleaching gel. According to the researchers, the effect of 10% carbamide peroxide bleaching process on enamel is similar to the effects of other general process, for example a dental prophylaxis, which takes up a 5 to 50 μm loss of enamel surface.

The data suggest that bleaching is a comparatively safe process but there are some researchers that have put concerns on structural changes to enamel surface that occur as a consequence of bleaching. According to our results using 20% carbamide peroxide and 35% carbamide peroxide (at-home bleaching) does not have any hazardous effect on the solubility of enamel surfaces. Maia et al [17] investigated the influence of 10% carbamide peroxide and 7.5% hydrogen peroxide on enamel microhardness. There was no statistically significant difference among the groups. The 7.5% hydrogen peroxide has shown a tendency to decrease the microhardness. In line with these results it is said that this at-home bleaching procedure is reliable for enamel surface. Furthermore, in our study, 20% carbamide peroxide (at-home bleaching) material, from its remineralization supporting property (which statistically was not so significant different), is having a better result when it is used in greater concentration bleaching materials. The use of the lower concentration of carbamide peroxide treatment may support enamel surface remineralization.

Tezel et al. [18] applied 38% hydrogen peroxide, 35% hydrogen peroxide and 10% carbamide peroxide to extracted teeth. Calcium concentration was investigated by a spectrophotometer. 38% and 35% hydrogen peroxide were statistically significant different but 10% carbamide peroxide does not significantly different from the control group. Similarly, 38% hydrogen peroxide (in-office

bleaching) used in the present study effected the enamel surface which was shown by increased enamel's solubility.

Bizhang et al. [19] applied 10% carbamide peroxide and 5.3% hydrogen peroxide to the enamel. They used fluoride to the first group only. In the non-fluoride group, median mineral loss was statistically significant higher than the others. The use of the fluoride treatment after bleaching may support remineralization of the tooth surface. Mondelli et al [20] evaluated the effects of bleaching treatments using different hydrogen peroxide concentrations on bovine enamel microhardness. They concluded that the bleaching protocols caused a slight alteration of the enamel surface. Although, the remineralization process minimized these effects. In our research, after carbamide peroxide applications, the fluoride was not applied to teeth because according to the manufacturer's directions it is not required. But, after 38% hydrogen peroxide applications the fluoride was applied to teeth according to the manufacturer's directions. If fluoride was not applied, it was thought that bleaching procedure was not correct. In spite of fluoride application, using 38% hydrogen peroxide effects on the surfaces of enamel and increases the solubility.

Conclusion

Within the limitations of this research, it can be concluded that;

- Using 20% carbamide peroxide and 35% carbamide peroxide (at-home bleaching) do not have any affect on the solubility of enamel surface.
- Using 38% hydrogen peroxide (in-office bleaching) effects the surface of the enamel and increases the solubility.
- It could be preferred to use 20% carbamide peroxide (at-home bleaching) since it supports enamel's remineralization.

References

1. Uysal T, Sisman A. Can previously bleached teeth be bonded safely using self-etching primer systems? *Angle Orthod.* 2008;78(4):711-5.
2. Uysal T, Basciftci FA, Usumez S, Sari Z, Buyukerkmen A. Can previously bleached teeth be bonded safely? *Am J Orthod Dent Orthop.* 2003;123(6):628-32.
3. Polydorou O, Möniting JS, Hellwig E, Aushill TM. Effect of in-office tooth bleaching on the microhardness of six dental esthetic restorative materials. *Dent Mater.* 2007;23(2):153-8.
4. Attin T, Kielbassa AM, Schwanenberg M, Hellwig E. Effect of fluoride treatment on remineralization of bleached enamel. *J Oral Rehabil.* 1997;24(4):282-6.
5. Sulieman M, Addy M, Macdonald E, Rees JS. A safety study in vitro for the effects of an in-office bleaching system on the integrity of enamel and dentine. *J Dent.* 2004;32(7):581-90.
6. Carvalho AO, Ayres AP, de Almeida LC, Briso AL, Rueggeberg FA, Giannini M. Effect of peroxide bleaching on the biaxial flexural strength and modulus of bovine dentin. *Eur J Dent.* 2015;9(2):246-50.

7. Joiner A. The bleaching of teeth: a review of the literature. *J Dent.* 2006;34(7):412-9.
8. Plotino G, Buono L, Grande NM, Pameijer CH, Somma F. Nonvital tooth bleaching: a review of the literature and clinical procedures. *J Endod.* 2008;34(4):394-407.
9. Santini A, Pulham CR, Rajab A, Ibbetson R. The effect of a 10% carbamide peroxide bleaching agent on the phosphate concentration of tooth enamel assessed by Raman spectroscopy. *Dent Traumatol.* 2008;24(2):220-3.
10. Pinto CF, Oliveira R, Cavalli V, Giannini M. Peroxide bleaching agent effects on enamel surface microhardness, roughness and morphology. *Braz Oral Res.* 2004;18(4):306-11.
11. Ustidal A, Uysal T, Akdogan G, Kurt G. Effect of 16% carbamide peroxide bleaching agent on the shear bond strength of orthodontic brackets. *World J Orthod.* 2009;10(3):211-5.
12. Nakamura T, Saito O, Ko T, Maruyama T. The effects of polishing and bleaching on the colour of discoloured teeth in vivo. *J Oral Rehabil.* 2001;28(11):1080-4.
13. Potocnik I, Kosec L, Gaspersic D. Effect of 10% carbamide peroxide bleaching gel on enamel microhardness, microstructure, and mineral content. *J Endod.* 2000;26(4):203-6.
14. Karadaş M, Seven N. Vital Tooth Bleaching. *J Dent Fac Atatürk Uni.* 2014;9:126-35.
15. Araujo EM, Baratieri LN, Vieira LC, Ritter AV. In situ effect of 10% carbamide peroxide on microhardness of human enamel: function of time. *J Esthet Restor Dent.* 2003;15(3):166-73.
16. McCracken MS, Haywood VB. Demineralization effects of 10 percent carbamide peroxide. *J Dent.* 1996;24(6):395-8.
17. Maia E, Baratieri LN, Caldeira de Andrada MA, Monteiro S, Jr., Vieira LC. The influence of two home-applied bleaching agents on enamel microhardness: an in situ study. *J Dent.* 2008;36(1):2-7.
18. Tezel H, Ertas OS, Ozata F, Dalgac H, Korkut ZO. Effect of bleaching agents on calcium loss from the enamel surface. *Quintessence Int.* 2007;38(4):339-47.
19. Bizhang M, Seemann R, Duve G, Römhild G, Altenburger JM, Jahn KR, Zimmer S. Demineralization effects of 2 bleaching procedures on enamel surfaces with and without post-treatment fluoride application. *Oper Dent.* 2006;31(6):705-9.
20. Mondelli RF, Gabriel TR, Rizzante FA, Magalhães AC, Soares Bombonatti JF, Ishikiriyama SK. Do different bleaching protocols affect the enamel microhardness?. *Eur J Dent.* 2015;9(1):25-30.