EFFECT OF FLUORIDE INCORPORATION IN BLEACHING AGENTS ON ENAMEL

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ABSTRACT

INTRODUCTION: Tooth bleaching has proven to be a conservative esthetic solution for tooth discoloration, hydrogen peroxide (HP) is used as an active oxidizing agent for tooth whitening; it can be used either directly or indirectly by chemical reaction from carbamide peroxide (CP). So many patients suffer from discomfort and sensitivity during and after the bleaching procedure. The use of fluoride shows to be beneficial in reducing the adverse effects of bleaching on Enamel.

OBJECTIVES: The study was designed to evaluate the effect of fluoride incorporation in bleaching agents on enamel surface properties.

MATERIALS AND METHODS: twenty sound human premolars extracted for orthodontic reasons were selected for the study. The selected premolars were randomly divided into 2 equal groups (10 teeth per group) as follows:

Study Group I: The teeth were bleached using 10% Carbamide peroxide.

Study Group II: The teeth were bleached using 10% CP containing 0.11% fluoride.

All the specimens were examined by scanning electron microscopy (SEM) and micro-hardness test.

RESULTS: after 14 days erosion pattern was noted in teeth from group 1 while the teeth of group 2 showed milder demineralization, group 1 showed significant decrease in micro-hardness compared to the base line whereas group 2 teeth that were treated with fluoridated bleaching agent showed insignificant reduction in micro-hardness.

CONCLUSIONS: incorporation of fluoride in bleaching agents reduces the adverse effects of bleaching on the enamel surface.

KEYWORDS: bleaching, fluoride, enamel, carbamide peroxide, demineralization.

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INTRODUCTION

Recently, the demand for more aesthetic appearance has increased which made tooth bleaching procedures more common in dental clinics as white teeth increases self-confidence and patient satisfaction (1, 2). Current bleaching techniques use oxidizing chemical agents including hydrogen peroxide and carbamide peroxide (3-5). Carbamide peroxide in turn decomposes into HP and urea (6).

HP causes denaturation of enamelin and amelogenin, which are organic proteins present in the organic enamel matrix. This could increase enamel permeability which in turn induce microstructural changes. On the other hand, urea induces alkalization, which may reduce demineralization of enamel (7, 8).

There are two types of teeth bleaching: vital and non-vital with several techniques for each method (9).

Non vital bleaching is needed in case of necrotic teeth or teeth that have been subjected to trauma as it causes pulp hemorrhage due to rupture of the blood vessels and precipitation of blood pigments and iron products causes staining of the tooth (10).

Non vital bleaching is done internally using sodium perborate mixed with 30% hydrogen peroxide applied in the pulp chamber and left for one week inside the tooth, this method is called modified waking bleach technique (11). Internal power bleaching can be done using 30-35% HP activated by light or heat and it can be combined with walking bleach technique between the visits (4).

Vital teeth bleaching can be performed in the clinic by the dentist using high concentrations of hydrogen peroxide

ranging from 25-40% and it can be activated by light or heat sources (in-office bleaching technique) the desired tooth shade can be achieved in one visit within one hour only divided into three or four sessions (12), the other technique is performed at home by the patients themselves using custom made trays inside which they apply the bleaching gel (at-home bleaching technique) also called night guard bleaching (13).

Most of home bleaching agents utilizes carbamide peroxide with low concentration (10-20%) applied on the teeth for several days as the 10% CP equals to 3.6% HP so it requires more time to provide the same effect (14).

CP has proved great results in teeth whitening and a long lasting effect (1). However; although tooth bleaching doesn't create macroscopically visible defects, some studies reported some undesirable microscopic alterations (15) which may include: Changes in the chemical composition of teeth, changes in the mineral content of dental structures such as calcium and phosphate, changes in enamel fluoride content, topographic changes, increase in enamel porosity and exposure of enamel prisms (16-18), other studies reported that the amount of calcium lost from enamel bleached with 10% CP was not clinically significant and the changes are not major (19).

Despite the proven safety of most of bleaching agents, patients still have concerns about the safety of bleaching procedures and also worry about tooth sensitivity afterwards (20). Transient tooth sensitivity was reported in most of patients during and after bleaching (21).

Dentists tend to assure the patients and to reduce the sensitivity using several methods such as using low concentrations of bleaching agents, temporary interruption

of whitening and use of remineralizing agents such as potassium nitrate and fluoride (22).

The use of fluoride during or after bleaching is very beneficial in remineralization of enamel and inhibition of the decrease in micro-hardness. The preferable concentration of fluoride that would be enough for hardening and remineralization of enamel is not known yet whether to be with small amount as 0.11%, or larger amounts as in fluoride varnish which is up to 2% (23).

Recently developed bleaching agents containing additional ingredients such as fluoride, potassium nitrate and calcium phosphate have been introduced to prevent either hypersensitivity or demineralization after tooth-whitening therapy (1, 24).

A study revealed that the incorporation of sodium fluoride in hydrogen peroxide bleaching agent generates fluoridated hydroxyapatite and calcium fluoride crystals on enamel surface (25).

In order for bleaching agents to lighten the color of the teeth they penetrate into dentin to some depth to decompose the intrinsic pigments, so the penetration of the oxidizing molecules maybe hindered by the precipitation of minerals crystals induced by fluoridation of the bleaching agent and this raises some concern about the efficacy of those types of bleaching agents in lightening the color of the teeth in comparison to the conventional types (1, 5, 26).

The effect of fluoride addition to bleaching agents on the physical properties and microstructure of enamel is controversial and yet to be determined.

MATERIALS AND METHODS

This study was conducted on 20 sound human premolars free from caries, cracks or any decalcification and extracted for orthodontic reasons, the teeth were cleaned after extraction and kept in saline solution until the time of experiment, The study was conducted after the approval of the Research Ethics Committee, Faculty of Dentistry Alexandria University.

Experimental procedure

The twenty teeth were grouped into two groups (10 teeth each)

study group 1: in which all the teeth were bleached using 10% carbamide peroxide (opalescence® 10%) (Ultradent, South Jordan, UT, USA).

study group 2: the teeth were bleached using 10% carbamide peroxide with 0.11% incorporated fluoride (opalescence PF® 10%) (Ultradent, South Jordan, UT, USA).

Teeth were cleaned using ultra sonic scaling instrument then polished with pumice powder, they were embedded in self-curing acrylic resin showing the buccal surface only on which the material was applied. In both groups the material was applied on the buccal surface of the teeth for 8 hours per day for a period of 14 days, the gel was removed after each application with tap water and the teeth were kept in artificial saliva until the next application in a dark room at 37°C.

Histological procedure:

The specimens of both groups were washed with distilled water to remove any debris and immediately fixed in 3% glutaraldehyde fixative. They were then dehydrated in ascending grades of alcohol (30%, 50%, 70%) for twenty minutes immersion in each solution, and glued to copper stubs. Eventually, they were sputter-coated with gold in a

fine coat and then examined under SEM (27). All specimens were observed at two magnifications (x1000 and x2000).

Microhardness test:

Specimens from each group were examined by vicker hardness testing machine (Figure 1) at load 50 for 5 seconds, the specimens undergone 3 hardness tests, first at base line, then after 14 days (at the end of the bleaching period), and eventually after 28 days (after recovery) (1).

Figure (1): Micro-Vickers hardness tester digital auto turret (Model MVD-402, Shanghai, PRC).

Statistical analysis

The collected data of the microhardness testing were statistically analyzed by using F test (ANOVA) to calculate micro hardness at 3 periods (baseline then at 14 days then at 28 days), comparison and significance between periods was done using post hoc test (Bonferroni).

The amount and percentage of change of micro hardness from the baseline to day 14 and day 28 was calculated using student t-test. Pairwise comparison between the 2 groups was done using Mann Whitney test by means of IBM SPSS software (Armonk, New York: IBM Corporation).

Data was presented as means, standard deviations and medians.

RESULTS

SEM results:

Study group 1:

The examination revealed significant erosion pattern close to type II etching pattern with loss of prism core and maintaining of the periphery (interprismatic dissolution) (Figure 2&3)

Study group 2:

In this group the demineralization is less distinct with minor loss of prism core and periphery (Figures 4&5)

Microhardness test Results

Figure (2): (SEM), (study group 1 bleached with 10% CP, at 14 days) showing irregular porous surface of enamel with erosive pattern X1000.

Figure (3): (SEM), (study group 1 bleached with 10% CP, at 14 days), showing erosion pattern close to that of type II etching with loss of prism core while retaining the periphery X2000.

Figure (4): (SEM), (study group 2 bleached with 10% CP with 0.11% incorporated fluoride, at 14 days) showing mild surface porosity and mild erosion X1000.

Figure (5): (SEM), (study group 2 bleached with 10% CP with 0.11% incorporated fluoride, at 14 days) showing minor dissolution of prism core and prism periphery X2000

Table (1) shows comparison between the three measurements of micro hardness at 3 periods (baseline. After 14 days and at day 28) in each group, where the mean values for group 1 are 246.7 ± 38.15 at baseline, 153.7 ± 27.08 at day 14 and 233.6 ± 37.59 at day 28 while for group 2 the mean values are 307.4 ± 38.02 , 278.0 ± 15.50 and 299.6 ± 31.40 respectively.

In group 1 the difference between the 3 periods was significant $p < 0.001$, hardness reduction after the bleaching period (day 14) was by 37% while for group 2 the difference was insignificant $p = 0.069$, and the hardness was reduced by 8.5%.

Table (1): Comparison between the three measurements of micro hardness at 3 periods (baseline. After 14 days and at day 28) in each group

Micro hardness	Baseline	After		F	p
		14 days	28 at recovery		
Study grp 1 (n=10)					
Median (Min. – Max.)	239.0(195.3 – 327.0)	149.7(113.4 – 197.4)	228.3(189.0 – 307.0)	21.595	<0.001*
Mean $\pm$ SD.	246.7 ± 38.15	153.7 ± 27.08	233.6 ± 37.59		
Ch		$\downarrow 93.04$	$\downarrow 13.16$		
% Ch		$\downarrow 37.22$	$\downarrow 3.36$		
Sig. bet. Periods	$p_1 < 0.001^*, p_2 = 1.000, p_3 = 0.003^*$				
Study grp 2 (n=10)					
Median (Min. – Max.)	296.7(249.9 – 387.9)	278.1(257.1 – 306.6)	298.0(248.0 – 349.9)	3.119	0.069
Mean $\pm$ SD.	307.4 ± 38.02	278.0 ± 15.50	299.6 ± 31.40		
Ch		$\downarrow 29.39$	$\downarrow 7.80$		
% Ch		$\downarrow 8.53$	$\downarrow 1.60$		

F: F test (ANOVA) with repeated measures, Sig. bet. periods was done using **Post Hoc Test (Bonferroni)**

p1: p value for comparing between baseline and after 14 days

p2: p value for comparing between baseline and after 28 at recovery

p3: p value for comparing between after 14 days and after 28 at recovery

*: Statistically significant at $p \leq 0.05$

Table 2 shows comparison between the two groups according to the amount and percentage of change in micro-hardness from baseline to after the bleaching period (14 days) and at recovery (day 28).

The mean value for amount of change in micro hardness at day 14 is 93.0 ± 35.2 for group 1 and 29.39 ± 37.0

for group 2, while at day 28 the values are 13.2 ± 56.2 and 7.8 ± 40.2 respectively.

For the percentage of change, the mean value in group 1 is 37.2 ± 10.2 and in group 2 is 8.5 ± 10.5 at day 14 while at day 28 the mean values are 3.4 ± 21.0 and 1.6 ± 13.1 respectively.

The difference between the two groups in both amount and percentage of change was significant at day 14 $p=0.001$ and <0.001 while at day 28 it was insignificant indicating recovery after hardness loss, $p=0.796$ and 0.739 respectively.

Table (2): comparison between the two groups according to the amount and percentage of change in micro-hardness from baseline to after the bleaching period (14 days) and at recovery (day 28).

Micro hardness	Study grp 1 (n=10)	Study grp 2 (n=10)	Test of sig.	p
Change from baseline to				
After 14 days				
Median (Min. – Max.)	90.1(42.1–175.1)	30.0(-22.2–111.9)	U=9.0*	0.001*
Mean $\pm$ SD.	93.0 $\pm$ 35.2	29.39 $\pm$ 37.0		
After 28 at recovery				
Median (Min. – Max.)	11.8(-74.3–103.3)	6.5(-70.6–77.4)	U=46.0	0.796
Mean $\pm$ SD.	13.2 $\pm$ 56.2	7.8 $\pm$ 40.2		
% Change from baseline to				
After 14 days				
Median (Min. – Max.)	38.6(19.6–53.6)	10.1(-8.9–28.9)	U=2.0*	<0.001*
Mean $\pm$ SD.	37.2 $\pm$ 10.2	8.5 $\pm$ 10.5		
After 28 at recovery				
Median (Min. – Max.)	5.0(-31.9–35.3)	2.3(-25.3–23.8)	U=45.0	0.739
Mean $\pm$ SD.	3.4 $\pm$ 21.0	1.6 $\pm$ 13.1		

t: Student t-test

U: Mann Whitney test

p: p value for comparing between the studied groups

*: Statistically significant at $p \leq 0.05$

DISCUSSION

In this study the human premolar teeth were selected as they are commonly extracted for orthodontic reasons even if they were sound, since this study required collecting large number of sound teeth to perform all the experimental tests.

Previous studies investigated the effect of fluoride containing bleaching agents on enamel (1, 7) and they are also highly used clinically but their efficacy is still controversial as the fluoride incorporation within the bleaching gel may raise a concern about the adverse interaction between the fluoride and carbamide peroxide since CP may hinder the remineralizing effect of fluoride (28). However, there are no sufficient proofs about the potential problems; hence the use of fluoride containing bleaching agents is supported.

A recent study reported that fluoridated bleaching agents rehardened the bleached enamel faster than conventional types (29), in the present study the use of the fluoridated bleaching gel produced a minor erosive pattern compared to the fluoride free gel where the erosion was significant, it also did not predispose the enamel to great hardness loss unlike the conventional type.

Although the negative effects of the bleaching on the enamel are dependent mainly on concentration and PH of

the bleaching agent (30, 31), some surface alterations are reported even with very low concentrations as in home bleaching using only 10% of carbamide peroxide (32).

In Scanning electron microscopy analysis haywood et al. (1990) reported that no changes in surface morphology occurred on using 10% carbamide peroxide home bleaching (33).

Leonard et al. confirmed the previous observations in that home bleaching with 10% CP did not alter the surface texture of enamel after 14 treatment days or after 6 months follow up examination (34). While Hegedus et al. (1999) observed that the surface of the samples became more irregular with deep surface grooves after bleaching with 10% carbamide peroxide for 28 hours (35).

Turkun et al. observed increase in enamel porosity following 14 treatment days with 10% CP, but it was reversed within 3 months following treatment (32).

Chen et al. (2008) reported that After a 2-week treatment period with 10% CP the specimens showed significant surface alteration and erosion pattern, whereas the specimens treated with the fluoride containing gel showed minor erosive pattern (1).

Regarding the hardness loss of enamel following the bleaching, it was highly variable in the literature; Potocnik et al. reported that the use of 10% CP didn't affect the hardness measured by Vicker's testing machine (19), Sasaki et al also showed no effect of CP on hardness (8), on the other hand, Azer et al and de Arruda et al. reported significant decrease in hardness and wear resistance (36, 37).

In the present study, reduction in micro-hardness was observed in both groups after 14 days treatment compared to the baseline but with different percentages. The fluoridated group showed insignificant reduction in hardness while the non-fluoridated one showed significant hardness loss, the same results were also reported by Chen et al. (1). However, after another 14 days (at day 28) the hardness recovered in both groups to values close to those of the baseline as in this experiment the teeth were kept in artificial saliva for 16 hours per day between the applications.

The saliva is considered as a natural source of remineralization restoring the minerals of the demineralized bleached enamel as Shannon et al. reported (38) and it also allows re-hardening of the enamel surface (39).

It should be taken in consideration that the regular bleaching group requires more than two weeks after the treatment is completed to regain its original hardness from saliva, during this period the erosive lesions will be susceptible to acid dissolution and also abrasion from tooth brushing. Although any changes are reversed after a period of time but milder demineralization and shorter recovery time will be safer for the tooth, that's why the fluoride incorporation is highly beneficial to prevent the adverse effects on tooth enamel during the bleaching treatment period.

CONCLUSION

The results suggest that fluoride incorporation in the bleaching gel produces less demineralization changes such as surface erosion and hardness reduction.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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