

Effects of Carbamide Peroxide and Thickening Carriers on Enamel Micro-hardness

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Abstract: Objective To evaluate the effect of carbamide peroxide (CP) bleaching agents of different concentration and three thickening carriers on enamel micro-hardness. **Methods** Thirty-six premolars with 2×2 mm grounded flats on buccal and lingual surfaces of each tooth were randomly assigned to six groups. Using Carbopol, PVP and Poloxamer as thickening agent respectively, bleaching gels containing 11%, 21% of CP and control gels without CP were applied on the enamel specimens for 2 weeks (6-8 h/d, 37 °C, 100% relative humidity). The micro-hardness of their surface was measured prior to and post the treatment. Groups treated with 21% CP were then immersed in artificial saliva 14 days; specimen was measured again at the end of 14th day. **Results** The micro-hardness of enamel treated with 11%CP has no significant change before or after the treatment ($p>0.05$); the micro-hardness of enamel treated with 21%CP was significantly reduced after bleaching ($p<0.01$); though immersing the treated specimen in artificial saliva for 2 weeks increased micro-hardness ($p<0.05$), it's still lower than those before bleached ($p<0.05$). There was no significant change of micro-hardness among groups treated with different carriers of the same CP ($p>0.05$) concentration, but changes of those treated with same thickening agent with different CP ($p<0.05$) concentration was significant. **Conclusion** Bleaching agent with 11%CP has no significant effect on enamel micro-hardness, while 21%CP can significantly reduce enamel micro-hardness. However, artificial saliva presented a remedy effect on the bleached enamel. Different thickening carriers have no significant effect on enamel micro-hardness.

Key words: teeth bleaching; carbamide peroxide; micro-hardness; enamel

INTRODUCTION

Since the introduction of night-guard vital bleaching in 1989 by Haywood and Heymann^[1], the night-guard vital bleaching has become the most popular teeth bleaching method due to its notable effect, simplicity of the method, and the advantage to protect the periodontal structure of tooth^[2]. Series of necessary accessory products have also become available now. As the major component of home bleaching agents, carbamide peroxide is the active ingredient of bleaching agents. Thickening carriers in the bleaching formula help prolong the release of this active ingredient of CP. Currently, carbopol is the most common thickening carriers in the bleaching formula; it is a less cross-linked acrylic polymer. Carbopol is acid in nature when dissolved in water; therefore it needs to be naturalized to pH 5.5-6.5 by sodium hydroxide. But the pH cannot be too high since hydrogen peroxide is stable under acid condition and will dissolve under alkaline condition. Carbopol is fine powder and will dissolve slowly in water. As the gel storage time increases, that fine powder, not yet dissolved, will finally dissolve. Thus the acidic group -COOH in its molecular structure exposed which may lower the pH value and then demineralize the enamel. There is no available scientific documentation to prove whether this process is true. PVP and poloxamer

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are the most common sustained releasing thickener in clinical use, though the effect on physical character of enamel is unknown. This paper studies how various thickening carriers and CP of different concentration in bleaching formula affect enamel micro-hardness of human teeth.

MATERIALS AND METHODS

1. Treatment agents

Using Carbopol, PVP, and poloxamer respectively as thickening carriers we make up bleaching formula with different concentration of CP: 11% and 21%, and also control gel without CP (product of Department of Dental Materials, College of Stomatology, the Fourth Military Medical University). Sodium hydroxide is used to adjust the pH to 6.5, and we apply them after placing the agents in room temperature for 2 weeks.

2. Experimental design

We selected 36 human premolars with root removed stored in physiological solution for no longer than 3 months. The premolars were sectioned in a mesiodistal direction in equal halves. The facial and lingual surfaces were separated and embedded in acrylic resin with 2×2 mm grounded flat surface exposing for bleaching applications. The 72 samples were randomly divided into 3 groups with 24 samples in each group. Then, each of the three groups was further divided into a, b, c subgroups. 1a, 2a, 3a were bleached by 11% CP with carbopol, PVP and poloxamer as thickening carriers respectively. 1b, 2b, 3b, were bleached by 21% CP using same thickening carriers. 1c, 2c, 3c were treated with control gel without CP using same thickening carriers. All three groups were treated six to eight hours per day for 2 weeks under 37 °C and 100% relative humidity. In between each treatment, the specimen were washed and kept in artificial saliva. Before and after treatment Viker's micro-hardness of enamel surface was measured by a Micromet 2100 Microhardness Tester (Buehler, USA). The enamel polished surface was indented four times per sample with a 50g load for 15s. Then the mean micro-hardness value was determined by averaging four measurement figures derived from four points of the sample surface. 1b, 2b, 3b were immersed into artificial saliva which is renewed every day for 2 weeks after each treatment and then the micro-hardness was measured. The result was analyzed by using Spss 10.0 software. Within groups, we compare the results of micro-hardness before and after the experimental period using paired t-test. Between groups, comparisons of treatment effects were made using one way analyses of variations and every two groups were compared by SNK-q test.

RESULTS

The micro-hardness of enamel surface before and after treatment in each group is shown by Table 1. Using carbopol, PVP, poloxamer as thickening carriers, there is no significant differences in the micro-hardness of enamel surface for the specimen treated with 11%CP for 2 weeks prior to or post the treatment ($p>0.05$); Specimen treated with 21%CP showed very significant difference in the degree of micro-hardness before and after the treatment ($p<0.01$). Nevertheless, immersing the treated specimen in artificial saliva for 2 weeks increased micro-hardness ($p<0.05$), which is still lower compared with the specimen without being bleached ($p<0.05$). There is no significant difference for specimen treated with control gel which contains no CP ($p>0.05$).

The differences of micro-hardness among each group before and after the treatment are shown by Table 1. Using 3 different thickening carriers respectively, there is no significant difference ($p>0.05$) in the micro-hardness in each group after two-week treatment with 11% CP (1a, 2a, 3a), 21 % CP (1b, 2b, 3b) and control gel without CP (1c, 2c, 3c). Using different CP concentration and carbopol as the thickening agent to treat 3 subgroups (1a, 1b,

1c), we measured statistical difference ($p < 0.05$) among the three groups. Between 1a and 1b, 1b and 1c regarding the micro-hardness, there is significant differences ($p < 0.05$). No significant differences were detected between 1a and 1c ($p > 0.05$). The subgroups (2a, 2b, 2c and 3a, 3b, 3c) bleached with formula using PVP, poloxamer as thickening carriers showed same results of changes in micro-hardness compared with 1a, 1b, 1c.

Table 1 Vicker's micro-hardness of enamel and difference before and after treatment (kg/mm²) (x ± s)

Carriers	Main groups	Subgroups	Baseline	2 weeks	4 weeks	difference value
Carbopol	1	1a(11%CP)	364.7 ± 25.2	349.3 ± 17.2		15.4 ± 28.5
		1b(21%CP)	380.1 ± 29.5	332.4 ± 26.0	355.7 ± 15.5	47.7 ± 31.5
		1c (0%CP)	345.1 ± 50.0	338.1 ± 32.4		7.0 ± 28.3
PVP	2	2a(11%CP)	346.1 ± 46.8	337.5 ± 37.0		8.7 ± 32.9
		2b(21%CP)	368.8 ± 43.1	321.0 ± 39.5	346.1 ± 37.4	47.8 ± 27.4
		2c (0%CP)	364.1 ± 28.2	352.0 ± 49.9		12.1 ± 26.7
Poloxamer	3	3a(11%CP)	338.2 ± 48.9	317.4 ± 24.9		20.8 ± 32.0
		3b(21%CP)	399.4 ± 24.0	349.0 ± 21.3	373.8 ± 38.5	50.4 ± 16.8
		3c (0%CP)	350.4 ± 22.7	337.6 ± 21.8		12.8 ± 19.1

DISCUSSION

A vital tooth bleaching is the first choice for dentists and their patients. During bleaching process, the bleaching agents are in directly contact with tooth surface for a long period of time. Therefore it is very important to understand the effect of bleaching formula on tooth structure. Micro-hardness provides indirect evidence for the loss or gain of mineral in human teeth. Some researches have indicated that there is no evident change in enamel micro-hardness after bleaching treatment. Oltu and Gurgan^[3] have confirmed that 10% and 16% CP in bleaching formula will make no change to enamel structure of treated tooth. McCracken and others^[4] believe the amount of calcium loss in enamel structure after 10% CP bleaching does not harm average micro-hardness, therefore has no clinical significance. But the majority of on-going studies supports that the oxidizing reaction could alter the chemical structure and morphology of enamel after being exposed to bleaching agents^[4-7]. The disputes among researchers may be related to other elements such as the length of bleaching, solution pH value, various types of human teeth, and methods used to store bleaching agents.

The critical pH for enamel demineralization to occur is between 5.2 and 5.8^[8]. During the bleaching process the release of hydrogen ions and perhydroxyl radicals makes the presence of H₂O₂ in carbamide peroxide decomposition, and thus decreasing the pH level. However, at the same time, urea, a by-product of carbamide peroxide decomposition, may raise the pH level which will remain elevated for almost 2 hours^[7]. Other researches suggest that mineral loss may not only be related to the CP concentration of bleaching formula^[9] and the higher amount of H₂O₂ released. Changes in enamel chemical structure and composition seem to occur after repeated exposures to whitening agent and could be associated with the pH level of a bleaching formula or some other compounds, such as fluoride ions, desensitizing agents, carbopol, or any other chemicals present at the time of treatment^[4]. This experiment uses carbopol, PVP, poloxamer as thickening carriers in order to prolong the release of active agents in bleaching formula thus strengthening the bleaching effect. McCracken and Haywood^[4] have documented minor decrease of enamel micro-hardness by using products containing carbopol. Considering the components which may change enamel mineral composition, this experiment has designed three groups of specimen using three thickening carriers containing no CP. The experiment not only studies the effect of thickening carriers on enamel surface but also provides equal hydration for the control samples. The results of current study indicated that the three carriers do not have significant impact on the micro-hardness of enamel. But whether there will be similar results if the storage time prolonged needs further research.

How to store bleached specimen seems to be an important factor for variations in the results we have

measured. In laboratory studies where neither saliva nor a buffered liquid was used to store specimen during the intervals between bleaching sessions, a reduction in micro-hardness was recorded ^[5]. However, when the specimen was stored in artificial saliva or in the oral medium of situ, no alteration was measured in the surface hardness of enamel ^[8]. Therefore, saliva has an apparent and potential remedial effect to restore the mineral composition of enamel to a certain degree due to its calcium-and phosphorus-saturated environment. Our experiment has also confirmed the same result. The micro-hardness of all the specimen treated with bleaching formula of 11% CP concentration with three different carriers indicate slight decrease in micro-hardness after bleaching, but the difference is too small to be considered significant ($p>0.05$). It is also true that the bleaching formula used in this study contains potassium nitrate and fluorides, which may indirectly protect enamel micro-harness of teeth ^[10]. Low levels of fluoride can remarkably inhibit mineral loss, because potassium is involved in the process of enamel mineralization, precipitating on the enamel matrix before calcium-phosphate association ^[11]. Therefore, bleaching treatment using formula that contains potassium nitrate will result in minimal change in the micro-hardness of specimen.

Some other researches show that bleaching formula of low pH level decreases the pH value of saliva in mouth in the first 5 minutes. In 15 minutes the saliva pH increases due to the saliva neutralization and breaking down of carbamide peroxide into urea ^[5]. The saliva flow and its high mineralization capacity in human mouth can increase the remineralization of bleached enamel ^[3], which also explained the reason why the micro-hardness slightly increased after bleaching in a few individual specimens. A few studies have shown that demineralized enamel is more susceptible to remineralization than intact enamel ^[8]. Therefore, in this study, even though the 11% CP thickening carrier has relatively low pH (6.5), it is neutralized immediately and loses its capacity of demineralization.

Higher concentration of CP accelerates the release of H_2O_2 which speeds the bleaching. After two weeks of treatment using 21% CP with different thickening carriers the micro-hardness significantly decreased ($p<0.01$). Even though we continued treatment with artificial saliva, the micro-hardness were apparently higher than the figures we measured right after the bleaching treatment ($p<0.05$), but still lower than the figures prior to the bleaching treatment ($p<0.05$). It is true that artificial saliva containing calcium ion and potassium ion helps increasing the enamel remineralization, but it cannot restore the mineralization to the same level before the bleaching treatment. The time duration and the cycle of the bleaching treatment are all controlled in the same way for 21% CP and 11% CP in our experiment. We still need further studies on if decrease in CP concentration will reduce the unfavorable result. Sufficient researches all agree that higher concentration of CP will lead to erosion of enamel micro-hardness, which will facilitate entry of opportunistic microflora^[5]. Therefore, high concentrations of CP in bleaching formula must be cautioned for any applications even though various differences occurred in reactions to such bleaching formulas.

Due to the large variations in the changes of enamel micro-hardness of the specimen, we compared the differences between the measurement figures of micro-hardness of each group both prior to and post the treatment. Our study showed that no significant change in micro-hardness among groups treated with different carriers with the same concentration of CP ($p>0.05$). There were significant changes in micro-hardness among groups treated with same thickening carrier with different concentration of CP ($p<0.05$). There were no significant differences between 11%CP group and control gel group ($p>0.05$), 21%CP group were statistically significant compared with 11%CP group and control gel respectively ($p<0.05$). Though bleaching agent with 11% CP and control gel without CP made no significant change in the enamel micro-hardness, the effect on dental sensitivity and surface morphology needs further studies.

Currently, most researches evaluating bleaching effect on teeth are conducted under the mimicking condition

of human mouth. Unfortunately this condition cannot be completely created just like a human mouth condition, more clinical trials and studies are highly necessary.

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(Edited by Joesmile, Jane Chen)