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Effect of Different Time Periods of Vital Bleaching on Flexural Strength of Bovine Enamel and Dentin Complex

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Abstract

Aim: The aim of this *in vitro* study was to evaluate the effect of 20% carbamide peroxide (CP) on the flexural strength (FS) of bovine enamel and dentin complex.

Methods and Materials: One hundred sound bovine teeth were selected for use. Blocks (2×3×8 mm) from the middle portion of the facial surfaces of each crown were sectioned from the teeth. The specimens were randomly divided into five groups (n=20) based on the time period of vital bleaching. Group 1 comprised the control group kept in artificial saliva. The experimental groups subjected to immersion in 20% CP, Opalescence, for four, six and eight weeks, respectively (eight hours daily). Mechanical testing was performed 24 hours after the last treatment using an Instron Universal Testing Machine with a crosshead speed of 0.5 mm/min. The results were analyzed by one-way analysis of variance (ANOVA) and Tukey's test (α=0.05).

Results: Mean values for FS were 141.27, 103.06, 120.71, 130.23, and 117.90 (Mpa), respectively. Statistically significant differences in FS were noted among the groups. A statistically significant difference was observed between Group 2 (two week bleach) and the control.

Conclusion: Application of 20% CP bleach for two weeks provided significant decreases in FS of bovine enamel and dentin complex. Similar decreases were not observed among the other groups.

Keywords: Vital bleaching, carbamide peroxide, flexural strength, enamel, dentin

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Introduction

There is a wide range of bleaching products and techniques that can be used to successfully lighten the shade of teeth. Tooth whitening with carbamide is one of most popular dental procedures, and it is also one of the least understood. The available information on safety and biological properties of peroxides for tooth whitening indicates minimal risks with appropriate use of the bleaching products.[1-3]

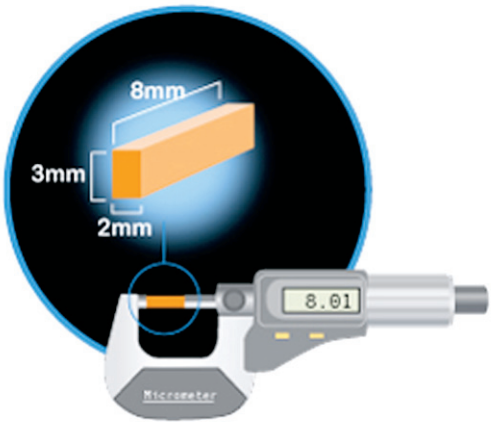
Carbamide peroxide (CP) dissociates into hydrogen peroxide and urea when in contact with soft tissue or saliva at oral temperatures. Peroxide can diffuse through enamel and dentin due to its low molecular weight. While hydrogen peroxide further degrades into oxygen and water, urea degrades into ammonia and carbon dioxide.[4] A general concern is expressed regarding possible weakening of the tooth structure.[5] It has been shown the fracture toughness of enamel was reduced about 30% after a 12 hour exposure to 10% CP.[6] Changes in mechanical properties indicate structural alterations are likely to occur in enamel exposed to bleaching agents.[7] Although some scanning electron microscopy (SEM) investigations of bleached enamel have shown little or no topographic alterations,[8-13] enamel surface changes such as porosity, pitting, erosion, and demineralization have been reported.[5,14-21]

Previous studies indicate bleaching with CP can significantly reduce the ultimate tensile strength of enamel, and no differences among the type and concentration of the bleaching agent were detected.[7,22] There were also significant reductions in flexural strength (FS) and flexural modulus of bovine dentin after two-week and two-month exposures to CP.[23]

The aim of this study was to investigate the effects of vital bleaching applied for different time periods on the FS of bovine enamel and dentin complex.

Methods and Materials

Rectangular beams measuring 8 mm in length by 2 mm in width by 3 mm in height were prepared from the middle of the facial surfaces of previously frozen extracted bovine incisors. The mean height and width of the specimens were measured using a digital micrometer to an accuracy of 0.01 mm at the three locations along the specimen length. The specimens were randomly divided into five groups (n=20). Group 1 comprised the control group receiving no bleaching treatment and was kept in artificial saliva at 37ºC for two weeks.



Treated groups were subjected to immersion in 20% CP, Opalescence (Ultra Dent Products Inc, South Jordan, UT, USA), for two, four, six, and eight weeks, respectively. They were exposed to a bleaching agent for eight hours daily, then specimens were thoroughly rinsed with deionized water for ten seconds and stored in artificial saliva at 37ºC. In an attempt to simulate the clinical scenario the bleaching regimens used in this *in vitro* study followed the recommendations of the respective manufacturers. The specimens were maintained in artificial saliva between each bleaching application period. After the end of the

bleaching time interval in each group, specimens were rinsed and stored in deionized water for 24 hours at 37ºC before being tested.

The specimens were subjected to a three-point-bend test (TPBT) on a Model 4301 Universal Uniaxial servo-mechanical testing machine (Instron Corporation, Canton, MA, USA) at a crosshead speed of 0.5 mm/min. FS was determined using the following formula:

$$FS=3P_fL / 2WH^2$$

Where P_f is the measured maximum load at the time of specimen fracture, L is the distance between supports on the tension surface (6 mm), W is the mean specimen width, and H is the mean height of the specimen between the tension and compression surfaces.

The results were subjected to statistical analyses using one-way analysis of variance (ANOVA) and the Tukey's test ($P<0.05$).

Results

The mean FS for each group is listed in Table 1. The FS values range from 103.06 ± 37.04 to 141.27 ± 29.94 Mpa. The ANOVA for the experimental groups revealed a statistically significant difference among them ($P<0.05$). The Turkey's test revealed a statistically significant difference ($P<0.05$) between Group 2 (two week bleach) and the control (Figure 1). This means there was a significant reduction in FS after two weeks exposure to CP. There were no statistically significant differences in the FS of specimens among the other groups ($P>0.05$).

Discussion

CP dissociates into hydrogen peroxide and urea. Despite the low hydrogen peroxide release, at-home tooth whitening materials are used over prolonged periods and for extensive application times. This raises concerns of possible damage to the hard tissue exposed to the high concentrations.[7] Two weeks of treatment were used to simulate the home-applied vital bleaching technique,[24] and two months of treatment were carried out to simulate conditions for patients receiving prolonged bleaching treatments indicated for tetracycline stains, for patients who re-bleach their teeth after regression of tooth whitening has occurred, and for patients who overuse the bleach in an ever-increasing desire to whiten their teeth.[23]

In the present study 20% CP was used because in a recent study no significant effect regarding the range of concentrations of the bleaching agents was observed.[7] The two-week treatment period resulted in a significant reduction in FS in comparison with the control group. This is in agreement with Tam et al.[23] Considering the high permeability of enamel to hydrogen peroxide, it is likely the entire thickness of enamel would be modified by such a treatment regime.[25] Porosities created by the bleaching agent along the exposed area of enamel may have acted as stress raisers during three-point bending tests.[7]

The main detrimental effects of bleaching enamel are related to surface morphological changes,[14-21] decreased enamel microhardness,[21,26,27] and a reduction of fracture toughness.[6] Urea may

Table 1. Flexural strength (FS) (Mpa) mean and standard deviation in experimental groups and control.

Experimental Groups	Mean ± SD
Control	141.27 ± 29.94
Group 2	103.06 ± 37.04
Group 3	120.71 ± 30.99
Group 4	130.23 ± 28.74
Group 5	117.90 ± 29.15

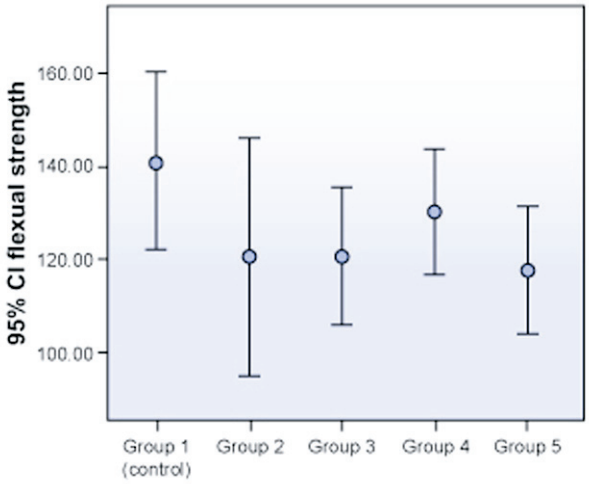
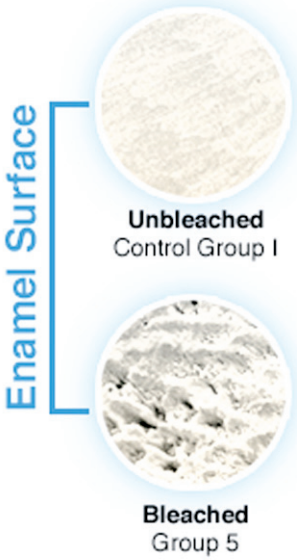


Figure 1. Comparison of FS in experimental groups (Mpa).



provide beneficial effects due to the increase in the pH of the bleaching solution.[4,9] However, due to its protein denaturing ability, it could also lead to interprismatic degradation of the enamel.[28]

The results showed there were no significant differences among the other groups. This is in contrast to the results of a previous study which demonstrated the FS of bleached dentin (10% CP) decreased further after two months and was significantly lower than the two month FS for unbleached dentin.[23] It has been shown saliva is a potent remineralizing solution, and its action on enamel can reverse the structural damage caused by bleaching agents or demineralizing solutions.[24,29] The use of the enamel and dentin complex together with artificial saliva were the probable causes of different results in the above mentioned study. It is not clear what caused the rebound of the FS at four, six, and eight week periods toward baseline values. In this context two hypotheses might be considered. First, remineralization might have occurred due to salivary action which could have compensated for the initial decrease in the FS of the specimens. Another explanation might be the softening of the tooth structure due to the reduction of fracture toughness which has caused an increasing resistance of the specimens to fracture at four, six, or eight week periods. Further studies to characterize microstructural changes in enamel and dentin structures are recommended.

Conclusions

Applications of 20% CP bleach for two weeks caused a statistically significant reduction in the FS of bovine enamel and dentin complex. Similar decreases were not observed among the other groups.

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