Change in pH of plaque and 10% carbamide peroxide solution during nightguard vital bleaching treatment

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The purpose of this study was to evaluate in vivo changes in the pH of plaque and of a 10% carbamide peroxide solution occurring within the bleaching guard during a 2-hour nightguard vital bleaching procedure. Baseline pH values for plaque and the carbamide peroxide solution were established. A small hole was placed in the anterior interproximal region of the guard to allow placement of the pH electrode. The pH of the carbamide peroxide solution was measured at 5-minute intervals. After 2 hours, the guard was removed and pH of the plaque was remeasured. The procedure was repeated three times on each of four subjects. The mean baseline pH reading for plaque was 6.31 and mean final pH reading was 6.86. The difference was statistically significant. At initial placement of the carbamide peroxide–filled guard, the mean intraguard pH was 4.50 (range of 2.80 to 7.80). The mean peak intraguard pH of 8.06 (range of 7.30 to 8.43), which was significantly different from baseline, was obtained within 31 minutes. The pH of plaque, saliva, and a 10% carbamide peroxide bleaching solution within the guard increased significantly during bleaching and remained significantly elevated for the duration of the study (2 hours). (Quintessence Int *1994;25:819–823.*)

Introduction

Nightguard vital bleaching (NGVB), or "dentist-prescribed home-applied" bleaching, has received much attention as an effective and simple method for lightening intrinsically stained or discolored teeth. In this technique a 10% carbamide peroxide (CP) solution is used in a custom-fitted guard. In spite of the increased acceptance and use of the NGVB technique,[1] questions remain concerning the effects of the pH of the bleaching solution on plaque and tooth structure.[2] The pH of bleaching solutions has been reported to range from 4.6 to 7.4.[3] A major concern when the bleaching technique is used with an acidic bleaching solution is possible enamel demineralization, which occurs at a pH lower than 5.2 to 5.8.[4] Because the NGVB technique may require the patient to wear the guard with the acidic pH solution 2 to 8 hours a day for up to 6 weeks, clinicians would not want to enhance the esthetic appearance of their patient's smile if there is a risk of dissolution of tooth structure.

A previous in vivo study evaluated changes in salivary pH occurring intraorally when a 10% carbamide peroxide bleaching solution (Proxigel, Reed & Carnrick) with a moderately low pH (pH 4.7) was used in a custom-fitted guard.[5] It was determined that salivary pH levels increased a statistically significant amount above resting salivary pH levels. Only during the first 5 minutes of treatment was the salivary pH level at or near the critical pH for enamel demineralization; otherwise the salivary pH level remained elevated above

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Fig 1 The pH meter, offset, and electrode used to measure the pH of the bleaching solution, plaque, and saliva.

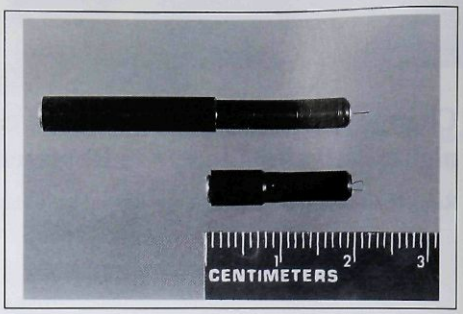

Fig 2 Electrodes used to measure the pH of the bleaching solution, plaque, and saliva.

baseline for at least 2 hours. However, changes in pH occurring in the guard (changes in the pH of the plaque and the bleaching solution) adjacent to the tooth were unknown.

Presently, no clinical studies exist concerning the in vivo changes in pH that occur inside the guard during use of any of the commercially available bleaching solutions. The specific objectives of this study were to evaluate in vivo, *(1)* the change in pH of a moderately low–pH 10% carbamide peroxide solution (Proxigel, pH 4.7) within the guard during a 2-hour NGVB procedure; and *(2)* the change in pH of plaque and saliva at the beginning and end of a 2-hour NGVB procedure that used a moderately low–pH CP solution (pH 4.7).

Method and materials

The research project was conducted in the Clinical Research Center at the University of North Carolina School of Dentistry, Chapel Hill, North Carolina. Participants for the study were adult volunteers from the School of Dentistry's Bleaching Studies Program, who agreed to the terms and conditions of the study and who signed an approved human-subjects consent form. Each subject had to be available for three 3-hour appointments. Four adult subjects participated in the study.

An irreversible hydrocolloid impression (Jeltrate Plus, LD Caulk) was made of the maxillary arch of each subject. Stone casts of the maxillary arch were generated and a bleaching guard was fabricated (0.02-inch, No. 31720 coping material, Buffalo Dental) with the original technique described by Haywood and Heymann.[6]

A total of 12 individual clinical sessions (three for each subject) were conducted in which changes in pH of saliva, the intraguard bleaching solution, and plaque were measured. The four subjects were instructed not to brush their maxillary teeth for 48 hours before each session to allow measurable plaque to accumulate. Subjects were also told not to drink, eat, or smoke for at least 2 hours before the beginning of each session. On arrival, each subject rested 5 minutes to allow stabilization of intraoral pH.

Measurements of pH were initiated with a pH/Temp meter (model 671P, Jenco Electronics) (Fig 1), and a Beetrode electrode (MEPH1 for saliva and MEPH3L for plaque, World Precision Instruments) (Fig 2). A BeeCal-Beetrode Offset (World Precision Instruments) was used to obtain pH scale readings instead of millivolt readings.

The collection technique for saliva and its pH measurement has been previously documented.[5] Four baseline reference points were established: *(1)* unstimulated (or resting) saliva, measured extraorally; *(2)* unstimulated saliva, measured intraorally; *(3)* tooth plaque before insertion of the nightguard; and *(4)* pH of the intraguard bleaching solution at insertion. A small hole was placed in the nightguard at the interproximal location between the right lateral and central incisors to provide access for the pH electrode (Figs 3 and 4).

The nightguard, half filled with the 10% CP bleaching solution, was inserted onto the maxillary teeth. The patient expectorated any excess CP. Cotton rolls were used to isolate the area, preventing salivary contamination through the access hole into the nightguard. Measurements of pH were taken by inserting the electrode

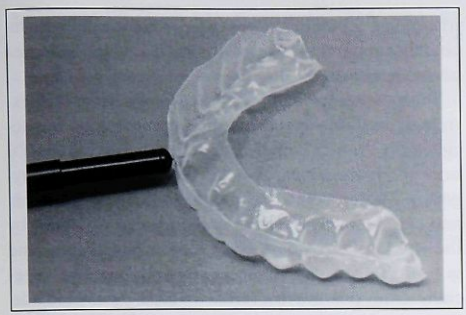

Fig 3 Insertion of the electrode through a small hole in the bleaching guard to measure changes in the pH of the bleaching solution during bleaching.

Fig 4 Measuring of the pH of the bleaching solution within the bleaching guard with an electrode.

Table 1 Changes in mean pH values of plaque and saliva after 2 hours of nightguard vital bleaching with a 10% carbamide peroxide solution

	Mean	SD
Plaque, initial	6.31	0.15
Plaque, final	6.86*	0.11
Extraoral saliva, initial	6.65	0.24
Extraoral saliva, final	7.10*	0.31
Intraoral saliva, initial	6.16	0.23
Intraoral saliva, final	6.73*	0.28

* Significantly different from baseline ($P < .03$).

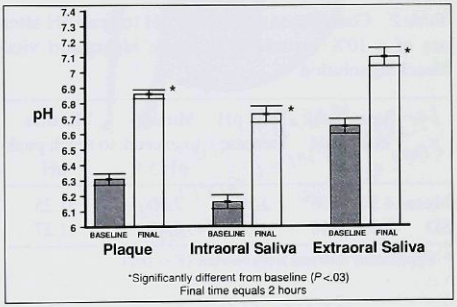

Fig 5 Changes in pH of plaque, intraoral saliva, and extraoral saliva during bleaching with 10% carbamide peroxide.

through the access hole in the nightguard. The pH values of the intraguard bleaching solution were recorded at 5-minute intervals for 2 hours. Baseline pH values (after insertion of the nightguard) of the bleaching solution at time zero were compared to the peak pH values and the value at 2 hours.

Plaque pH values were determined at baseline and on removal after the guard filled with the bleaching solution had been worn for 2 hours. The anterior tooth with the most interproximal plaque before bleaching was selected for the study. The baseline plaque pH value at time zero was compared to the pH value at 2 hours.

Intraoral and extraoral salivary pH readings were taken at baseline and at the end of the 2-hour experiment.

For each item measured (salivary pH, plaque pH, and bleaching solution pH), the mean change from the three sessions was calculated for each subject. Paired *t* tests were used to determine whether the mean of the subjects' mean changes was significantly different from zero. The level of significance was set at .05.

Results

Mean baseline and final pH readings for plaque, intraoral saliva, and extraoral saliva are shown in Table 1 and Fig 5. All differences (approximately 0.50 pH units) between initial and final pH readings were statistically significant ($P < .03$; paired *t* test).

At initial placement of the filled guard, the mean intraguard pH was 4.50 (SD = 1.24). The maximum dif-

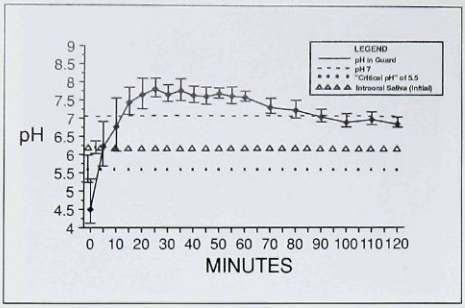

Fig 6 Intraguard changes in pH over time during use of a 10% carbamide peroxide bleaching solution.

Table 2 Comparison of baseline pH to peak pH after use of a 10% carbamide peroxide nightguard vital bleaching solution

	Base-line	Peak pH	Total pH increase	Minutes to exceed pH 5.5	Minutes to reach peak pH
Mean	4.50	8.06*	3.56	7.50	31.25
SD	1.24	0.16	0.70	2.47	11.27

* Significantly different from baseline ($P < .002$).

ference in pH within the guard (peak pH minus intraguard baseline) was a positive 3.56 pH units with a standard deviation of 0.70. The mean peak intraguard pH of 8.06 (SD = 0.16) was obtained within 31 minutes and was significantly higher than the baseline intraguard pH ($P < .002$) (Table 2). In 75% of the clinical trials, the intraguard pH of the bleaching solution exceeded pH 5.50 in 5 minutes or less. The average intraguard pH for all subjects exceeded pH 5.50 within 7.5 minutes. At the end of 2 hours, a slight decline from the mean peak pH occurred; however, the pH remained significantly higher than at baseline by 2.40 pH units ($P < .003$) (Fig 6).

Discussion

Ten percent carbamide peroxide is also known as *urea peroxide, hydrogen peroxide carbamide, or perhydrol-urea.* Historically, 10% CP has been used intraorally for treatment of minor oral inflammation and denture irritations.[7] Zinner et al[8] reported beneficial effects, including a reduction in gingivitis scores, when 10% urea peroxide was used.

Ten percent carbamide peroxide solutions are extremely unstable intraorally, and immediately disassociate into 3% to 5% hydrogen peroxide and 7% to 10% urea.[9,10] Hydrogen peroxide further degrades into oxygen and water, while the urea degrades into ammonia and carbondioxide.[9] These reactions are catalyzed by the enzymes peroxidase and catalase, which are found in most body fluids, tissues, and some bacteria, especially gram-positive bacteria.[11,12] Hydrogen peroxide, the active ingredient in carbamide peroxide, is a nontoxic, nonallergenic, antimicrobial agent capable of killing a broad range of microorganisms.[8,11] Urea is a nontoxic bacteriostatic substance capable of dissolving necrotic tissue, allowing wounds to heal more quickly.[7] The release of ammonia and carbon dioxide during degredation of urea elevates the pH,[9] thus reducing the concern that tooth structure will be demineralized during NGVB.

The results of this study showed that the pH of a moderately low–pH (pH 4.7) 10% carbamide peroxide bleaching solution became significantly higher when the solution was used as a bleaching agent during a 2-hour NGVB procedure. This increase in the pH level of carbamide peroxide also influenced the pH level of plaque, raising it as well. Concerns about the potential of NGVB to demineralize enamel or cause caries when a moderately low–pH (pH $\geq$ 4.7) bleaching agent is used seem unwarranted.

In 75% of the clinical trials, the critical pH (5.50) necessary to cause enamel demineralization was exceeded within 5 minutes and the pH remained significantly elevated for the duration of the 2-hour procedure. The average intraguard pH for all subjects exceeded pH 5.50 within 7.5 minutes.

Acknowledgments

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