Use of different concentrations of carbamide peroxide for bleaching teeth: An in vitro study

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Objective: *This in vitro study compared the shade changes in extracted teeth during 2 weeks' whitening with 5%, 10%, or 16% carbamide peroxide.*
Method and materials: *After color calibration, the sole examiner selected 110 extracted unrestored, noncarious teeth, shade A3 or darker on a value-oriented guide. The teeth were randomly distributed into equal color groups. The control group (11 teeth) was treated with 0.9% saline, while the experimental groups (33 teeth each) were treated with 5%, 10%, or 16% carbamide peroxide. The solutions remained on the teeth for 8 hours. The teeth and tray were rinsed with tap water for 2 minutes, then rehydrated in 0.9% saline for 16 hours in the humidifier. The shade was assessed, and the process was repeated daily for 2 weeks.*
Results: *Repeated-measures analysis of variance indicated a significant difference in overall shade values between the control and all carbamide peroxide–treated groups at days 8 and 15. A Kaplan-Meier Survival Analysis indicated a quicker two-tab color change for the 10% and 16% groups than the 5% group. However, continuation of the 5% treatment to 3 weeks resulted in shades that approached the 2-week 10% and 16% values.*
Conclusion: *Lower concentrations of carbamide peroxide take longer to whiten teeth but eventually achieve the same result as higher concentrations. Higher concentrations may cause increased sensitivity.*
(Quintessence Int 1998;29:503–507)

Key words: carbamide peroxide, color change, nightguard vital bleaching, shade guide

Clinical relevance

The efficacy of nightguard vital bleaching is a combination of concentration of solution and time of treatment. Results from this in vitro study show 5%, 10%, and 16% carbamide peroxide whitening gels to ultimately produce the same shade change.

Since its introduction by Haywood and Heymann[1] in 1989, nightguard vital bleaching has gained acceptance among dentists as an effective and simple method of lightening intrinsically stained or discolored teeth. Also referred to as "dentist-prescribed home-applied"[2] whitening, the original technique involved application of a 10% carbamide peroxide (CP) whitening solution containing Carbopol (carboxypolymethylene, B. F. Goodrich) in a custom-fitted (0.02-inch) plastic nightguard[3] for 6 to 8 hours a night. Positive results were usually achieved in 2 to 6 weeks. Modifications, improvements, and variations in the clinical technique now include *(1)* wearing a softer custom-fitted guard (such as 0.035-inch Sof-Tray, Ultradent), which may or may not contact soft tissue; *(2)* using varying concentrations of carbamide peroxide or hydrogen peroxide whitening solution; *(3)* applying the solution for one or more intervals during the day; and *(4)* increasing the amount of Carbopol.[4–16]

It has been claimed by some clinicians and manufacturers that solutions with concentrations higher than 10% are more effective (ie, whitening results are obtained more quickly than with the 10% CP). However, no controlled clinical trials exist to support this claim. Concern exists that an increase in patient-reported side effects (tooth sensitivity and gingival irritation) might result from an increased percentage of CP and Carbopol in whitening solutions. A previous study of a viscous 10% CP solution with Carbopol, used in a rigid tray, has documented side effects in 67% or more of the patients undergoing the nightguard vital bleaching technique.[17]

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TABLE 1 Number assigned to Vita shade tabs*

Vita tab	B1	A1	B2	D2	A2	C1	C2	D4	A3	D3	B3	A3.5	B4	C3	A4	C4
Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

*Arranged from lightest to darkest, according to manufacturer.

TABLE 2 Average numerical shade value of teeth after exposure to varying concentrations of carbamide peroxide over time*

Solution	Day 0	Day 8	Day 15
Saline control	12.8	12.8	12.9
5% carbamide peroxide	12.2 (range: 9–16)	9.6 (range: 3–14)	8.4 (range: 3–13)
10% carbamide peroxide	12.5 (range: 10–16)	9.7 (range: 3–16)	7.4 (range: 2–14)
16% carbamide peroxide	12.7 (range: 9–16)	9.0 (range: 3–16)	7.6 (range: 2–16)

*Lower number is a lighter tooth.

The purpose of this in vitro experiment was to determine the differences in shade change among 5%, 10%, and 16% CP Carbopol-containing solutions used on extracted teeth. The hypothesis is that a higher concentration of CP will yield a significant difference in color change compared to a lower concentration.

Method and materials

After color-calibration exercises to match teeth to the Vita shade guide (Vita Zahnfabrik), the sole examiner selected 110 freshly extracted, unrestored, noncarious teeth (incisors, canines, and premolars) of Vita shade A3 or darker for the study. Any hard or soft tissue remaining on any tooth after extraction was removed. All teeth were soaked in OMNI disinfectant (Cottrell) for 1 hour, then cleaned with flour of pumice in a rubber cup used in a slow-speed handpiece. The teeth were stored in 0.9% saline solution until the experiment began.

The teeth were randomly distributed into four groups, three experimental (5%, 10%, and 16% CP, Nite White Classic, Discus Dental) and one control group (saline). Each of the three treated groups contained 33 teeth, and the control group contained 11 teeth. The baseline shade of each tooth was assessed with a Vita shade guide. Each group was matched for baseline shade differences.

The root of each tooth was embedded in dental wax inside a plastic dentoform, and exposed cementum was sealed with clear nail polish. Each dentoform was numbered to identify each tooth. An alginate impression (Jeltrate Plus, Caulk/Dentsply) was taken, and a stone cast was generated. The 0.035-inch whitening tray was fabricated, according to the manufacturer's instructions, with facial reservoirs and a scalloped guard covering only the enamel of each tooth.

Each group was treated with the appropriate whitening solution (saline, 5%, 10%, or 16% CP) for 8 hours, in accordance with the manufacturer's instructions. Any excess whitening solution extruding from the mouthguard was removed. During treatment, all teeth, including the controls, were maintained in airtight containers (occlusal surfaces down) inside a humidifier at 37°C; moist paper towels were placed in the bottom of the container. After the 8-hour exposure time, both the teeth and the whitening tray were cleaned with a toothbrush and rinsed with tap water for 2 minutes. The teeth were then allowed to rehydrate in a 0.9% saline solution for 16 hours inside the humidifier.

After rehydration, a new shade assessment was made in natural and fluorescent light against a blue background. The examiner did not have access to the previous day's shade. The shade change was measured by using the Vita shade guide, arranged in order of value, according to the manufacturer's listing. For statistical purposes, a numerical value was assigned to each tab (Table 1). A positive numerical value for shade change denoted that the tooth was getting lighter. At baseline, all groups were statistically matched for shade (Table 2). The experiment continued in the same fashion for 2 weeks. Photographs were taken throughout the study.

Statistical analysis using repeated-measures analysis of variance was performed to determine if a significant difference ($P < .05$) existed among the various carbamide peroxide concentrations and enamel shade changes at day 8 and day 15. A Kaplan-Meier Survival Analysis was used to determine the quickness of the color change.

Figs 1a to 1c Example of shade change from treatment with 5% CP solution.

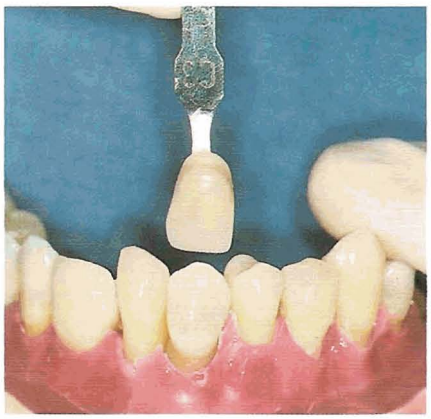

Fig 1a Baseline shade, C3.

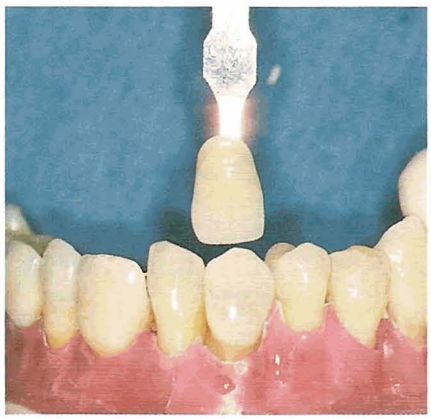

Fig 1b Seven days' whitening to shade A3.5 (2 units of shade change from baseline).

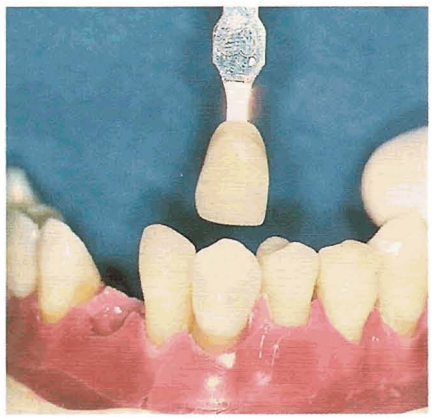

Fig 1c Fourteen days' whitening to shade C2 (7 units of shade change from baseline).

TABLE 3 Average numerical shade change of groups over time*

Solution	Day 8	Day 15	Day 22
Saline control	0.0	–0.1	NA
5% carbamide peroxide	2.6	3.8	4.8
10% carbamide peroxide	2.8	5.1	NA
16% carbamide peroxide	3.8	5.1	NA

*Positive number is lighter.
NA = not applicable.

TABLE 4 Shade changes of incisors and canines* with different concentrations of carbamide peroxide

	No. of Vita shade changes	
Carbamide peroxide	Incisors	Canines
5%	4.3	3.8
10%	4.1	5.3
16%	4.9	6.0

*Not enough premolars were tested to draw a valid conclusion.

Results

The results of the study are shown in Tables 2 and 3 and Figs 1 to 3. At the conclusion of the whitening process (day 15), there was a statistically significant difference between the control group and the three treated groups in the average shade change ($P < .01$). However no statistically significant difference existed for shade values among the CP-treated groups at day 8 or day 15 ($P < .05$). Descriptively, the 16% CP-treated group had a greater average change at day 8 than did the 10%, 5%, and control groups. At day 15, the 16% and 10% CP-treated groups had greater average change than did the 5% and control groups.

The time to reach critical whiteness, defined as a two-tab shade change in value from baseline score, occurred more quickly for the 16% and 10% CP-treated groups than for the 5% CP group (Kaplan-Meier Survival Analysis; $P < .01$). Continuation of the 5% CP treatment for a third week resulted in shades that approached the 2-week change values achieved by 10% and 16% CP. After several days of whitening, white spots appeared on several teeth. However, they soon disappeared or blended in as the rest of the tooth became whiter.

Comparison of the average shade change of incisors and canines indicated that the canines responded better to the 16% whitening solution than to the 5% or 10% solution (Table 4). This observation may be of clinical importance because canines are usually the darkest anterior tooth.

Discussion

The purpose of this in vitro study was to determine if a difference in whitening could be found after a fixed time interval of use of 5%, 10%, and 16% carbamide

Figs 2a to 2c Example of shade change from treatment with 10% CP solution.

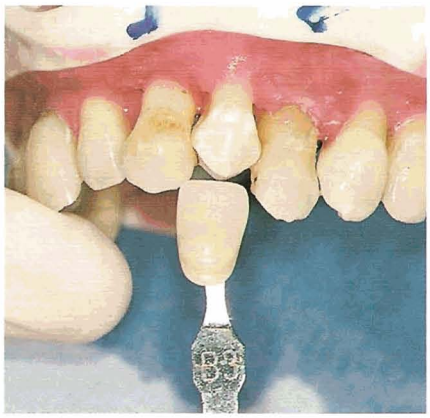

Fig 2a Baseline shade, B3.

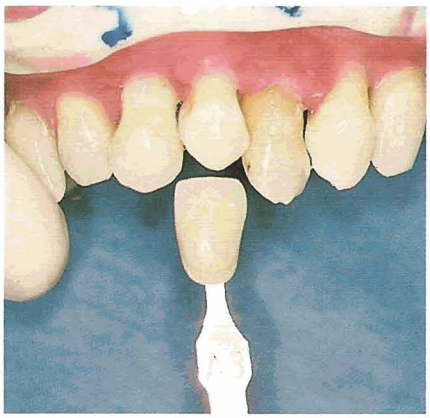

Fig 2b Seven days' whitening to shade A3 (2 units of shade change from baseline).

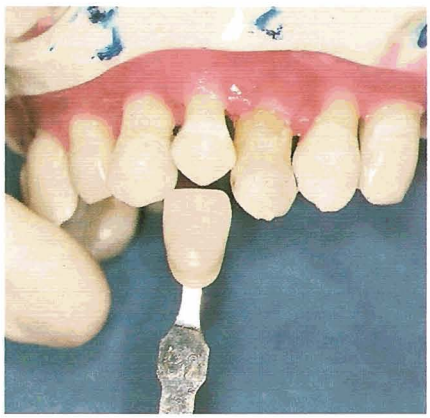

Fig 2c Fourteen days' whitening to shade B2 (8 units of shade change from baseline).

Figs 3a to 3c Example of shade change from treatment with 16% CP solution.

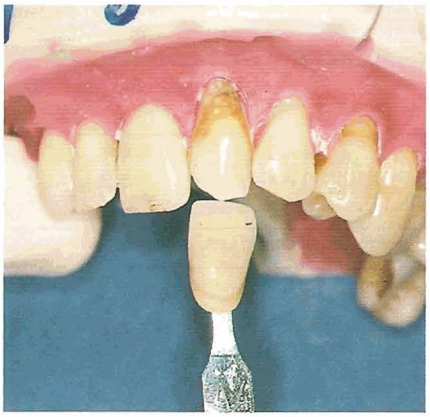

Fig 3a Baseline shade, A4.

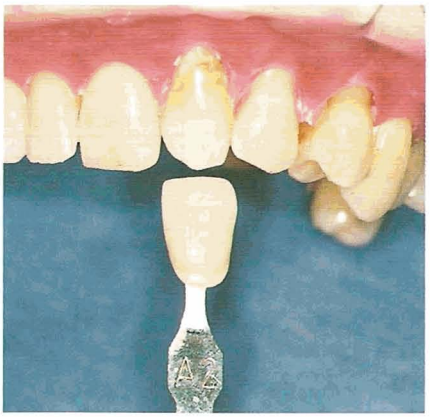

Fig 3b Seven days' whitening to shade A2 (10 units of shade change from baseline).

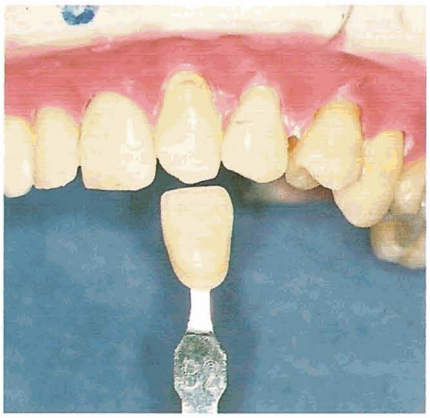

Fig 3c Fourteen days' whitening to shade B2 (12 units of change from baseline).

peroxide whitening solutions containing Carbopol. Results showed 5%, 10%, and 16% CP whitening gels to be statistically the same with respect to in vitro shade change on extracted teeth. Although there was no statistically significant difference in the color of the three experimental groups at week 1 and week 2, it is noteworthy that the change was faster with the higher concentration solution and slower with the lower concentration material. This would indicate that, although practitioners cannot expect all patients to experience faster whitening with the higher concentration CP, some patients probably will obtain faster results. Conversely, if a lower concentration material is used, some teeth may require a longer time to whiten to their optimum color.

When teeth are to be whitened, it would be prudent to use a product that is as efficacious as possible but causes minimal side effects. Further studies are needed to evaluate the difference in side effects caused by the various whitening gels. Hypothetically, use of 5% CP gels would result in fewer side effects than the gels with concentrations of 16% CP or higher while providing a similar shade change. However, whenever time is important and the need for a quicker shade change overrides concerns about possible side effects, a higher concentration of carbamide peroxide could be used.

Summary

A 2-week regimen of in vitro tooth whitening resulted in no statistically significant differences in tooth shade change among 5%, 10%, and 16% CP-treated groups at week 1 or week 2. However, a two-tab shade change occurred more rapidly for the 16% CP group than for the 10% CP and 5% CP groups at week 1, and the change occurred more quickly for the 16% and 10% CP groups than for the 5% CP group at week 2 ($P < .05$). By week 3, however, the values of the 5% CP group approached the week 2 values of the other two experimental groups.

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Answers to QI 5/98 Questions

1. D	5. B	9. B	13. D
2. B	6. C	10. D	14. D
3. C	7. C	11. A	15. D
4. C	8. D	12. C	16. D