Color change following vital bleaching of
tetracycline-stained teeth

Carolyn F.G. Wilson, DDS, MSD  N. Sue Seale, DDS, MSD

Abstract

A technique currently used to bleach intrinsically stained vital teeth in humans was studied to quantify the amount of color alteration attained by the process. The components of the bleaching technique, 35% hydrogen peroxide at 142°F, were applied to the labial surfaces of the canine teeth of 5 dogs. These experimental teeth, which were vital and tetracycline stained, were divided into 4 groups with respect to duration of application of the bleaching technique: 0 (control), 15, 30, and 45 min. The teeth were treated at their respective duration times every other week for a total of 4 sessions. Observation times for assessing stability of color removal were at 13, 62, 92 days after the final bleaching. Four examiners rated the teeth for color density, before and after each bleaching and at the follow-up sessions, by comparing the teeth to a custom-made porcelain shade guide. The control teeth did not change color significantly. The teeth treated for 15 and 30 min became significantly and progressively lighter through the 4 bleachings. The teeth treated for 45 min lightened significantly and progressively through the second bleaching, and then did not significantly lighten further. The color change of all teeth was stable at the follow-up times.

The discoloration of teeth as a side effect of tetracycline ingestion is a serious concern to both patient and dentist. Although tetracycline was introduced for use in 1948, this unesthetic side effect was not reported in the literature until 1956 by Shwachman and Schuster. This staining is now a well-known side effect addressed by package inserts and the Physician’s Desk Reference; however, cases of this drug-induced discoloration continue to appear in the literature. Reasons for the perpetuation of tooth staining may include diseases and conditions for which tetracycline is the drug of choice, as well as the physician’s failure to recognize the severity of the dental discolorations and significance of this side effect when prescribing an antibiotic for a child.

The poor esthetics and subsequent associated psychological and social problems caused by tetracycline-stained teeth are the primary reasons for pursuing an effective, enduring method of altering or restoring these teeth to their natural color. Full-coverage crowns and veneers are less than ideal, especially in the young patient. Therefore, a more conservative and cost-effective method of regaining natural tooth color has been sought.

External bleaching of vital teeth to improve esthetic appearance of intrinsically stained teeth is an accepted procedure. Clinicians have described methods for bleaching vital teeth using the superficial application of 30-35% hydrogen peroxide with its bleaching activity intensified by the application of heat. Tetracycline-stained teeth have been treated by this technique, with heat temperatures ranging from 88 to 165°F, by numerous investigators. However, Myers stated that the teeth darkened again 4 days postbleaching. Cohen bleached unstained human premolars with hydrogen peroxide and heat and found these teeth to remain lighter for at least 30 days. The frequency and length of applications have varied; however, reports have indicated that multiple applications of heat and bleaching are needed to attain the best esthetic results.

Previous evaluations of the bleaching technique have been made with regard to patient comfort, pulpal response, and clinical assessment of color alteration. However, the degree of color change related to the duration of the bleaching procedure has not been investigated. The objective of this study was to evaluate the effect of different bleaching application times on color changes in tetracycline-stained teeth of dogs.
Methods and Materials

Five healthy dogs chosen from a litter of 6 were used. These animals were fed tetracycline HCl mixed with their feed at a dose of 22 mg/kg of body weight every day for 90 days. Drug administration began when the animals were 6 weeks old. The sixth animal received no drug and served as the control animal. The 5 dogs receiving tetracycline presented a dentition stained bright yellow, secondary to tetracycline ingestion during formation of their permanent dentition. The control animal had normal, white teeth.

A custom porcelain shade guide was fabricated to approximate the range of yellow tetracycline-stained teeth. These 20 porcelain tabs then were evaluated for yellow pigment density. A digital reflection densitometer precalibrated to the yellow spectrum was used to produce the color density measurements. When each tab was placed under the aperture of the densitometer, it displayed an LED readout ranging from 1.00 to 0.00 which was the diffuse reflection density of yellow pigment in the tab. These digital readings of color density were used to measure color change.

Two rheostat-controlled bleaching instruments were calibrated and used as heat sources during the bleaching procedures.

The animals were approximately 16 months old at the first treatment. Prior to the bleaching procedure, each dog received intravenous pentobarbital sodium anesthesia at a dosage of 33 mg/kg of body weight. The 4 canine teeth of each animal were the study teeth. Four independent examiners compared these teeth on each experimental animal to the calibrated shade guide and their color evaluations were recorded.

The teeth of each animal were divided into 4 groups and were bleached in the following manner. The canine teeth were isolated using a rubber dam. Group A had a cotton pledget soaked in 35% hydrogen peroxide placed on the labial surface. Heat of 142°F then was applied at intervals of 1 sec on and 8 sec off for a duration of 15 min. Group B received the same bleach and heat treatment modality for a duration of 30 min. Group C received the same bleach and heat treatment modality for a duration of 45 min. Group D served as the control tooth for each animal and received no treatment. Each of the groups contained a total of 5 teeth. Following each bleaching procedure the teeth were rinsed with water. Upon removal of the rubber dam, the teeth again were compared to the calibrated shade guide by each examiner and the shades were recorded. The entire procedure, from induction of anesthesia and prebleach comparisons to the shade guide through the posttreatment comparisons was repeated 3 more times at 2-week intervals. At the third bleaching session 1 of the 4 examiners was unavailable for making the color comparison.

Following the 4 treatment sessions, 3 time periods were chosen for tooth evaluation to determine the stability of the color change produced by the bleaching procedures. Thirteen days after the last treatment 1 of the experimental animals was anesthetized as previously described. The 4 canine teeth of this animal again were compared to the calibrated shade guide by all examiners and the shades were recorded. This animal then was sacrificed and perfused with formalin for histologic examination of the teeth in the companion pulp study.

Sixty-two days after the final bleaching, 2 of the remaining animals had their teeth compared to the custom shade guide by 3 examiners. One examiner was unavailable at this session. Two animals then were sacrificed and the canine teeth removed for histologic investigation.

Ninety-two days after the final bleaching proce-

<table>
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<th>Source</th>
<th>df</th>
<th>MS</th>
<th>P</th>
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<tbody>
<tr>
<td>Duration of application (D)</td>
<td>3</td>
<td>0.0738</td>
<td>56.4541**</td>
</tr>
<tr>
<td>Number of sessions (S)</td>
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<td>0.0335</td>
<td>25.6302**</td>
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<td>Duration x sessions (DxS)</td>
<td>9</td>
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<td>Duration x sessions x animal</td>
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* p < .05; ** p < .01. df = degrees of freedom. MS = mean squares. F = Fisher's exact probability ratio.
dure the 2 remaining dogs were anesthetized. Three examiners again compared the dogs’ teeth to the shade guide to judge color stability. These 2 animals then were sacrificed for the companion study.

The data of all color comparisons were compiled and compared for the units of color density. The duration of bleaching for each group was compared to the others. A 2-factor analysis of variance (ANOVA) was used to determine simple main effects and the presence or absence of a significant interaction between the 2 time factors. Interrater reliability was assessed to determine consistency among the 4 examiners.

**Results**

The Pearson product moment coefficient was used to calculate the interrater reliability of the 4 independent examiners and showed consistently significant correlations in scores among the raters across sessions and durations (p < .01). The ANOVA summary in Table 1 shows that the duration of application has a significant effect (p < .01) in the color alterations. It also was found that the number of bleaching sessions resulting in the same degree of lightening varied significantly (p < .05) with the durations of application.

The effect of the number of sessions represented the more general effect averaged over the 4 durations (Table 2).

For the 15-, 30-, and 45-min applications of bleach and heat, there were significant differences in color change across the various bleaching sessions. Analysis of trend for these durations showed significant direct linear relationships for both the 15- and 30-min applications (p < .01) and a curvilinear relationship for the 45-min application. These trends are illustrated graphically in Figure 1 which demonstrates the relationships among the 4 durations of application and the number of treatment sessions. A positive change in units of color density along the Y-axis represents a lightening of the teeth, i.e., the mean decrease in color density has been plotted as a positive instead of a negative value. The X-axis represents the number of bleaching sessions. The points for each duration of application represent mean change in color density observed by the 4 examiners. The linear regression equations for the 2 direct linear relationships are in parentheses above their respective line drawings.

In the evaluation of color stability, the 2-factor ANOVA demonstrated no significant difference in the altered color of any of the treated teeth at any of the 3 follow-up periods.

**Discussion**

It was necessary to fabricate a custom shade guide because commercially available shade guides do not simulate the yellow spectrum of the tetracycline-stained teeth, especially as they become lighter. This may be the reason previous investigators did not find their shade guides useful, and therefore did not include those data in their publications.

Young animals with freshly erupted teeth were chosen to simulate the teeth of young human patients who are likely candidates for bleaching techniques. Because newly erupted teeth are more porous and their tetracycline stains are most often in the yellow spectrum, these teeth appear to respond more dramatically to the application of 35% hydrogen peroxide and heat.

The effects of the different durations of bleach and heat application were recognized at the first treat-

<table>
<thead>
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<th>Table 2. Summary Table of Simple Main Effects of the Four Treatment Sessions at Each Duration of Application</th>
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<tr>
<td>Source</td>
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<td>-----------------------------------------------</td>
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<td>Session (S)/at 0 duration (D_1)</td>
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<td>Sessions (S)/at 15 min (D_2)</td>
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<td>Session (S)/at 30 min (D_3)</td>
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<td>Sessions (S)/at 45 min (D_4)</td>
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<td>Duration x sessions x animals (DxSxA)</td>
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* p < .05. \( df = \) degree of freedom. \( SS = \) sum of squares. \( MS = \) mean squares. \( F = \) Fisher’s exact probability ratio.

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ment session with all 4 examiners noting the great amount of tooth lightening in the 45-min group with little change in either of the other treatment groups. By the end of the fourth session, the examiners saw no significant differences in the lightness of the teeth in all 3 treatment groups. All durations of application of bleach and heat produced a dramatic lightening of the teeth over 4 sessions, which was esthetically acceptable. The bleached teeth were almost the same shade as the control teeth.

Observation for judging stability of the color removal revealed no significant change in postbleaching color at any of the 3 assessment times. The stability of this color alteration, lasting at least 3 months, is in direct contrast to the studies by Myers and Walton. Myers bleached tetracycline-stained rat teeth either once or twice for 20 min a session. He found that the treated teeth looked lighter immediately after bleaching, but they looked essentially the same color as the adjacent untreated teeth 4 days after bleaching. Walton bleached tetracycline-stained primary dog teeth twice for 20 min each session and found that the treated teeth returned to their original shade; however, the time it took for this color reversal was unspecified. In both of these previous studies, the maximum cumulative bleaching time was 40 min, whereas, the minimum cumulative bleaching time was 60 min in this study. Cohen bleached human premolars for a cumulative bleaching time of 90 min and found the lighter shade he achieved to remain stable for at least 1 month. Therefore, these differences in stability indicate that the total treatment time may have some influence on the permanence of the color alteration as well as the degree to which the teeth are lightened.

Summary and Conclusions

All teeth receiving the 35% hydrogen peroxide and heat treatments became significantly lighter (p < .05) over the 4 sessions. Both the duration of application and the number of sessions showed a significant effect (p < .01) on color alteration. There was also a significant interaction (p < .05) between the durations and sessions. The 15- and 30-min duration groups exhibited a direct linear relationship between the units of color change and number of treatments. The 45-min duration of application showed a sharp increase in color change through the second session and then no further significant color change was seen. The control group did not show any significant color alteration during the 4 treatment sessions. At the 13-, 62-, and 92-day postbleaching observation times, all color changes in the treated teeth remained stable.

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