

Boston Oral Health
Resource Center

Forsyth Institute



ADA Seal of Acceptance Certification Study for BriteSmile

Final Report

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Executive Summary

Purpose and Experimental Design. The safety and effectiveness of the BriteSmile in-office tooth whitening system was evaluated in a 6-month randomized, blinded and controlled clinical trial. Eighty-seven subjects were selected for having dark shades of anterior teeth (D4 or darker) and were randomly assigned to one of three treatment groups. The anterior teeth of the test group (the peroxide + light treatment group) were treated for one hour by the combined application of a gel containing 15% peroxide and irradiation with a high-intensity light (the standard BriteSmile treatment). One control group (the peroxide control) received only the topical application of the 15% peroxide gel. The second control group (the light control) received application of a placebo gel (no peroxide) and light irradiation. This experimental design permitted evaluation of the combined peroxide + light treatment with peroxide alone and light alone to determine the relative safety and effectiveness of the combination therapy relative to the individual components of the treatment.

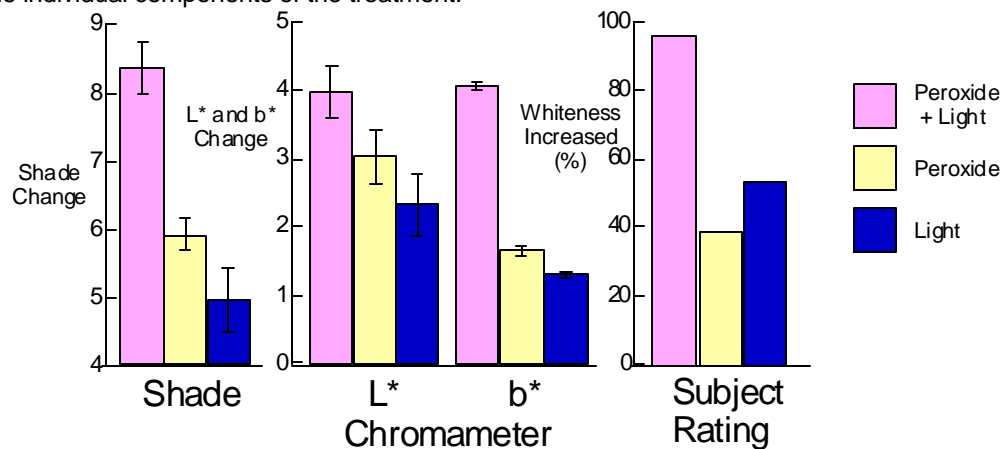


Figure 1. A comparison of changes related to tooth color following treatment by three independent measures. Results were summarized as shade (left panel), increased whiteness (L^*) and decreased yellowness (b^*) by chromameter measurement (middle panel) and percent of subjects rating the whiteness change to be "moderately" increased to "greatly" increased (right panel). Results in all cases were that changes in the peroxide + light treatment group were significantly greater than in the control groups.

Effectiveness: The peroxide + light treatment reduced the professional evaluated tooth shade by an average of 8.3 shade guide units and maintained 86.1% of this change over the 6-month evaluation period. This change was significantly greater than that observed with either of the control treatments. Similarly, measurement of tooth color change by chromameter revealed a significant increase in whiteness (L^*) and a significant reduction in yellowness (b^*). Both the whiteness increase and yellowness reduction were significantly greater than that measured following either of the control treatments. The statistical significance of yellowness reduction compared to control groups was maintained for the 6-month measurement period. Subject evaluation of the treatment response by questionnaire indicated that a significantly greater percentage of subjects considered the whiteness

increase to be at the highest response levels compared to subjects in either of the control groups. It was therefore concluded that efficacy superiority of the peroxide + light (BriteSmile) treatment relative to both controls was confirmed by three independent measures; the professional dentist saw it (shade change), the instrument saw it (chromameter) and the subjects saw it (questionnaire). These independent observations have been summarized in the preceding figure.

Safety. Safety was evaluated by professional dental evaluation of oral tissues, gingival index, plaque index and subject questionnaires. Analysis of responses from subject questionnaires indicated that a post-treatment increase in tooth sensitivity was experienced by approximately 20% of subjects treated either by the peroxide + light or peroxide alone. At the 3 and 6-month visits, no residual tooth sensitivity was reported. Analysis of data from the professional evaluation of gingiva also suggested that a transient increase in gingival redness occurred in 11.6% of the subjects. Analysis of gingival index data indicated that signs of gingival irritation were not seen at the 3 and 6-month visits. In the peroxide + light treated group, gingival index was significantly lower at 6 months than before treatment.

Summary. All evidence supports the conclusion that the peroxide + light treatment (BriteSmile) significantly lightens the color of teeth to a greater extent than peroxide alone or light alone. Furthermore, it is clear that the tooth lightening effect lasts for the 6-months of the study and may last for several years. The data also indicate that side effects occur at low frequency, rapidly disappear and do not compromise the health of the teeth, gingiva or oral mucosa. The results of this study support the claim that the BriteSmile treatment is both safe and effective.

Purpose

The BriteSmile 2000 Tooth Whitening System is an in-office tooth whitening system. The procedure includes application of a peroxide gel to the tooth surface under highly controlled conditions and subsequent exposure to high intensity light. The purpose of this study was to determine the ability of the BriteSmile 2000 Tooth Whitening System to significantly whiten teeth, to test for side effects that might occur and to validate the synergistic effect of combined peroxide and light application. The overall objective of this clinical trial was to provide clinical support for obtaining an ADA (American Dental Association) seal to claim that the BriteSmile system was safe and effective. It was one of two replicate studies required for this application.

Introduction

Tooth whitening

The pursuit of personal esthetics has led to a quest for white teeth, which has been considered to be a sign of health, youth and beauty. Currently, a number of options are available to whiten teeth. These include:

1. In-office whitening
2. Dentist dispensed at home use whitening, and;
3. Over-the-counter tooth whitening products.

In general, all tooth-whitening products have contained either hydrogen peroxide or carbamide peroxide as the active tooth whitening ingredients. The main differences between products were the concentration of peroxide and the method of use. In-office products have typically contained 30 to 35% hydrogen peroxide and whitening was performed in the dental office after isolation of soft tissues of the mouth. Dentist dispensed systems typically contains 10% carbamide peroxide or 3% hydrogen peroxide and whitening was performed by placing a peroxide preparation in a tray custom fabricated by a dentist. The tray was then worn over the teeth to achieve a desired whitening effect. Over-the-counter products have generally tended to be toothpastes containing an abrasive and/or a peroxide source.

BriteSmile Inc. has developed an In-Office tooth whitening system called BriteSmile 2000. This system is considered to be unique when compared to other ADA accepted, professionally applied bleaching products because it has utilized a pH 6.5, 15% hydrogen peroxide gel in combination with a curing type gas-plasma light (BriteSmile light) to accelerate the whitening process. In contrast, currently ADA accepted products contain 30% hydrogen peroxide +/- sodium perborate that may be used in combination with a heat lamp to improve the whitening efficacy (Anonymous1998).

As indicated above, the BriteSmile system utilizes a gas-plasma light to accelerate the kinetics of stain removal. Spectral analysis of the gas-plasma light indicated that the wavelengths and energy levels are comparable to the Demetron Optilux 500 curing light.

Laboratory evaluation of the BriteSmile 2000 system conforming to the guidelines set forth in Acceptance Program Guidelines for Home-Use Tooth Whitening Products (ADA Council on Scientific Affairs, May 1998) was completed. Results of these studies showed that the BriteSmile system would not soften enamel or composite restorations. Scanning electron microscopy studies have confirmed these findings and demonstrated that the system will not cause surface changes in enamel and restorative materials.

An exploratory clinical trial that consisted of 50 subjects was also completed. The results of this showed an average shade improvement of approximately nine after one hour of treatment period. Clinical examinations of the hard and soft tissues did not show any adverse effects indicating that the clinical safety profile was similar to currently accepted products.

It is well known that preparations containing peroxides have whitened teeth. However, the effects of the light on the improvement of clinical efficacy were unclear. Hence, the purpose of this study was to evaluate the BriteSmile 2000 system for consideration of an ADA seal of acceptance by evaluating the safety and clinical efficacy of the BriteSmile Light tooth whitening procedure.

The American Dental Association has not developed guidelines for a separate acceptance of in-office tooth whitening procedures; hence, this clinical trial was designed in accordance with the Acceptance Program Guidelines for home-use tooth whitening products (ADA Council on Scientific Affairs, May 1998).

Material and Methods

Experimental design - overview

The study was a parallel design clinical trial of eighty-seven subjects randomly assigned to three experimental groups (29 subjects/experimental group). The experimental groups were:

1. The test group (Peroxide + light, the full BriteSmile therapy; BriteSmile light plus the 15% hydrogen peroxide gel).
2. The peroxide control group. (BriteSmile 15% hydrogen peroxide gel alone)
3. The light control group (BriteSmile light alone with a placebo gel).

Treatments were blinded to the examiner and to the subject (as far as possible; i.e. the lack of a light in group 2 could not be blinded to the subject). The duration of each procedure was one hour. Tooth color measurements were subjectively evaluated using a standard Vita Shade guide and objectively evaluated using a chromameter (Minolta CR 321). Safety was evaluated by professional oral examination and subject questionnaire.

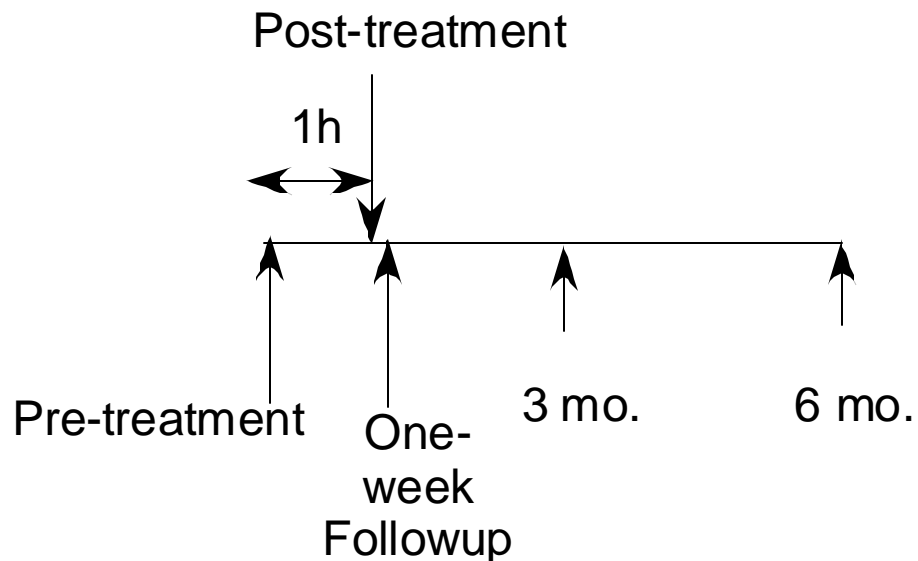


Figure 2. Time points at which response evaluations occurred

This report documents observations that were made over the pre- to post-treatment period. A subsequent report has described results obtained at 3 and 6 months.

Inclusion Criteria

1. Presence of four maxillary incisors.
2. Signed informed consent form.
3. Good general health as evidenced by the medical history.
4. Ages 18 to 65 (male or female).
5. Availability for the 6-month duration of the study.
6. Have not undergone a professional whitening treatment.
7. Minimum shade of Vita D4 or darker on maxillary central incisors

Exclusion Criteria

1. Presence of orthodontic appliances.
2. A soft or hard tissue tumor of the oral cavity.
3. Carious lesions requiring immediate treatment.
4. Restorations on all anterior teeth, which will interfere with color measurement procedures.
5. Advanced periodontal disease (characterized by the presence of purulent exudate, tooth mobility and/or extensive alveolar bone loss).
6. Is participating in another clinical study or panel test.
7. Pregnant women or women who are breast-feeding.
8. Congenital tooth stains or dental defects.

Test protocol

The primary outcome variable of this study was change in tooth color. Tooth color was measured using two procedures as recommended by the ADA for submissions of other whitening products (Anonymous 1994). Subjective color measurements were obtained using the Vita Shade Guide (VitaPan classical) and objective measurements were obtained using a Minolta CR231 Chromameter. Shade guide values were recorded on teeth #'s 7, 8, 9, and 10. Chromameter measurements were made with the acquisition of a maxillary impression and fabricating color measurement jigs ((Kowitz et al. 1994b; Kowitz et al. 1994a; Nathoo et al. 1994)). All shade guide color evaluations were carried out under standard color corrected operator light by the same investigator to avoid inter-investigator variability. The ordering of shades (B1, A1, B2, D2, A2, C1, C2, D4, A3, D3, B3, A3.5, B4, C3, A4, C4) in the guide was that recommended by the manufacturer for evaluation of degree of brightness. In this report, color measurements were obtained at pre-treatment and post-treatment. Subsequent analysis will provide information obtained at 3 month and 6-month recall. A 35mm photographic record of the whitening process was maintained for submission purposes.

To fulfill the criteria of a blind clinical trial, the investigator responsible for measuring the color was required to leave the operatories while the treatments were performed as described below.

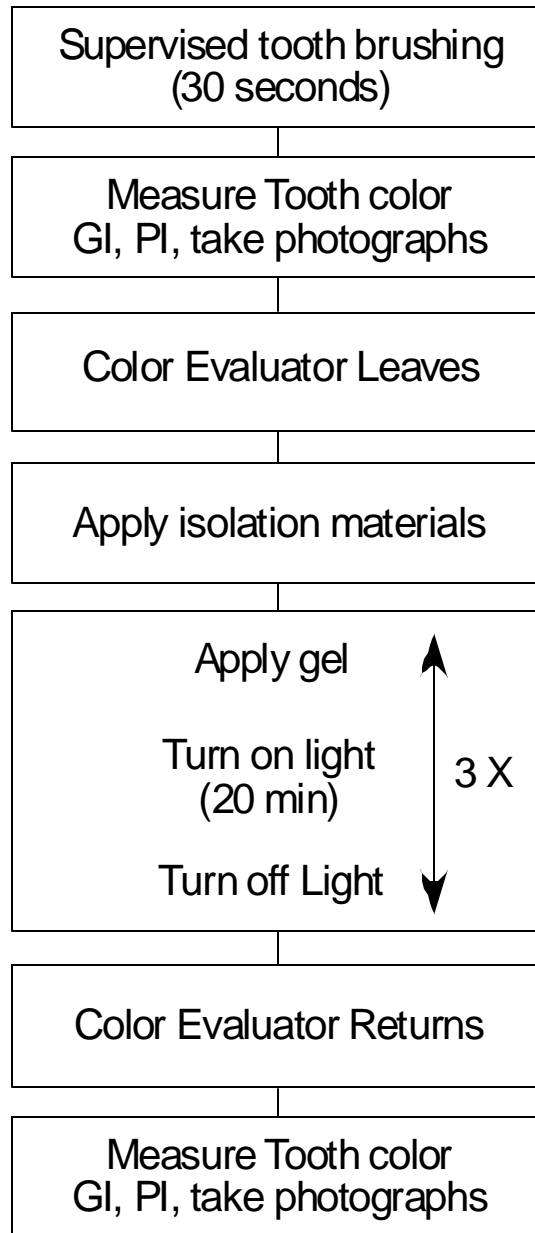


Figure 3. Protocol of the treatment study. The applied gel was either 15% peroxide gel or placebo gel. Group 2 (peroxide control) did not have light applied.

Tooth Isolation

One of the important characteristics of the in-office application procedure is the isolation and protection of delicate tissues. Applying a “brush-on” isolation material, that extended approximately 1 mm onto the tooth surfaces, protected the maxillary and mandibular gingiva surrounding teeth. This product, called “Opaldam” is a commercially available dental soft tissue isolation material, which is used to protect the gingival tissues during dental procedures. A cheek retractor is placed to hold the skin and lips away from the treatment area. Cotton rolls are placed in the cheek vestibules to control saliva build-up. A bite block is inserted into the subject’s mouth, to provide a jaw rest. Vaseline Petroleum Jelly is applied to the lips and sun block is applied to the lips. A saliva ejector is placed in the mouth will remove excess saliva. Subject preparation is illustrated in the following figure.

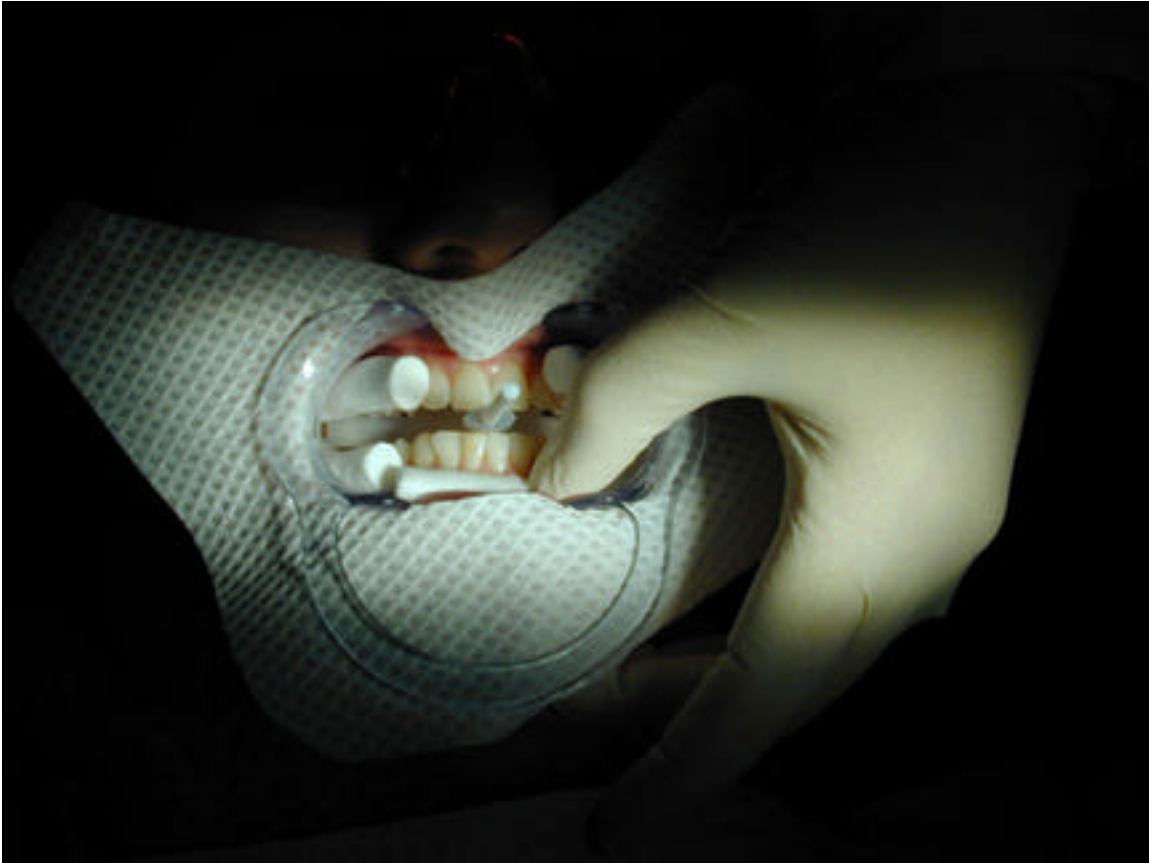


Figure 4: Procedure for isolation of teeth in order to be whitened. A cheek retractor, a face pad, cotton rolls and a light positing aid are illustrated. Opaldam is applied to the gingival, and sunscreen is applied to lips and any exposed mucosal area.

Approximately 2 mm of the gel (active or placebo) is applied to the buccal surfaces of maxillary and mandibular anterior teeth using a brush. All the incisors, cuspids and the bicuspids are covered to ensure easy access. Prior to light application, the subject and the operator staff are provided orange-tinted protective eyewear. The following figure illustrates the light treatment position.

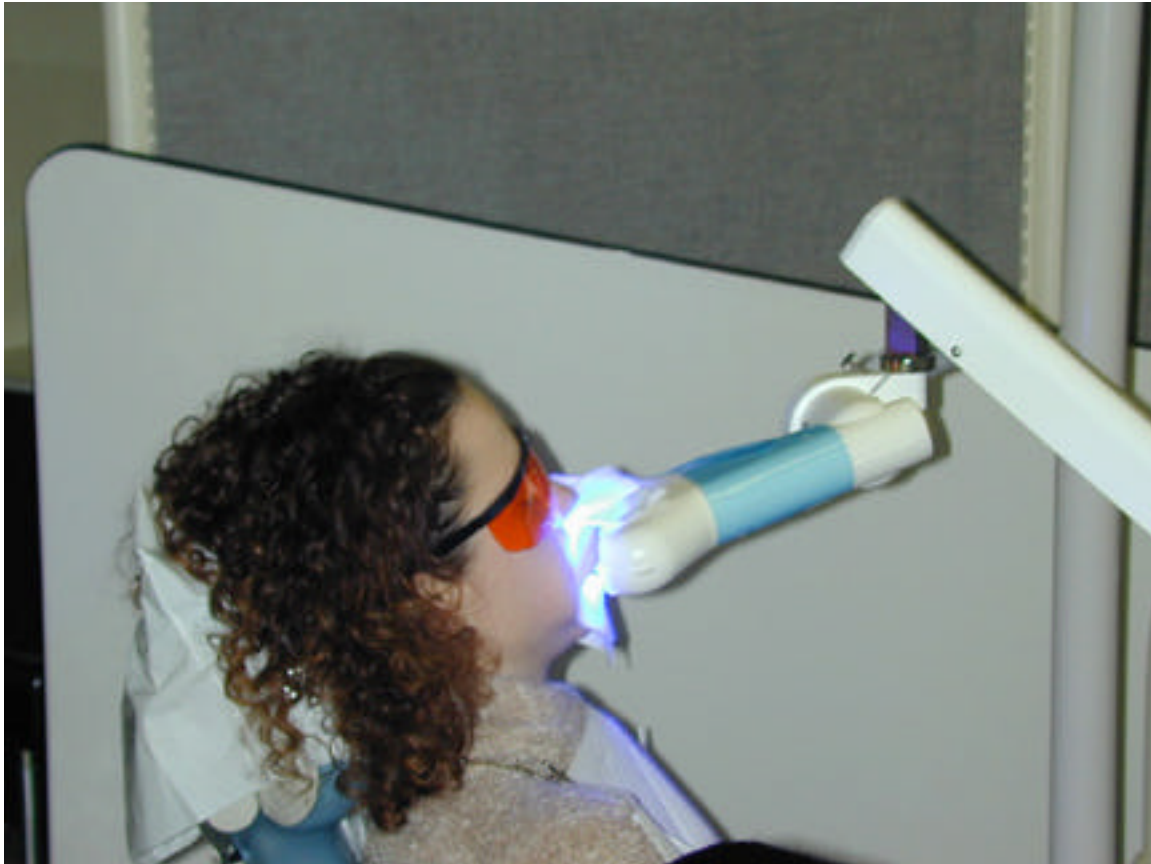


Figure 5. Subject in position for light irradiation of the teeth.

Calibration of the BriteSmile Gas-Plasma Light.

The light intensity was calibrated using standard light meter (Model LM-10 power meter head attached to Model FM meter, Coherent, Auburn, CA). The light intensity was set to a level of 130-160 mV/cm² and checked at least once daily.

Gingival and Plaque Evaluation

Gingival and plaque indices are recorded on all maxillary and mandibular teeth from the first molar forward at each evaluation period: pre-treatment, post-treatment, 3-month recall and 6 month recall. These indices are recorded in the GI/PI Evaluation Form (Appendix V). The criteria for these indices is as follows:

Gingival Index of Loe and Silness.

0 = Normal gingiva.

1 = Mild; slight color change; slight edema.

2 = Moderate; Redness and Glazing.

3 = Severe; Marked redness and edema; ulceration; spontaneous bleeding.

Plaque Index of Loe and Silness.

0 = No plaque.

1 = Film at gingival margin: remove plaque with probe.

2 = Moderate; seen with naked eye.

3 = Abundance of material.

Colorimetric Analysis

An objective method for the evaluation of changes in tooth color has been through the use of reflectance spectroscopy. Currently, manufacturers use reflectance spectrophotometers (colorimeters) for quality control of color matching in ceramics, paint and plastics.

The Commission Internationale d'Eclairage (CIE) has developed the LAB color mode as an international color standard to overcome device dependency of the RGB and CMYK modes and to linearize the color space coordinates produced by the tristimulus coordinate system. In a digital LAB color image, each color was uniquely specified by the three coordinate values of L^* , a^* and b^* . The Lightness coordinate (L^*) went from 0 (black) to 100 (white). The a^* coordinate went from +80 (red) to -80 (green). The b^* coordinate went from +80 (yellow) to -80 (blue) (Berger-Schunn 1994). This relationship was illustrated in the following figure.

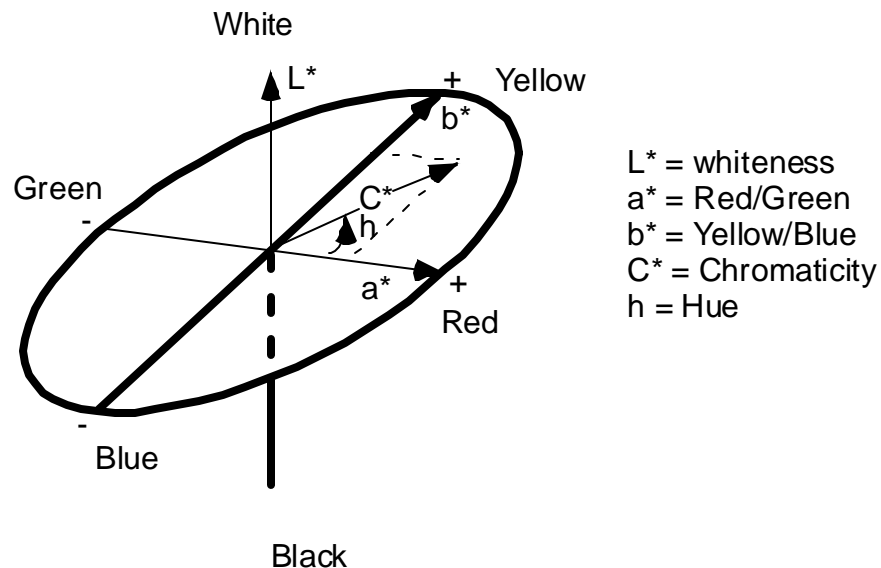


Figure 6. CIELAB color space.

The Minolta Chromameter has been used in several studies to evaluate tooth color change resulting from whitening procedures (Rustogi & Curtis, 1994), (Meyers et al. 1995; Rosenstiel et al. 1996), (Matis et al. 1998; Ouellet et al. 1992). In practice, the L^* component (Lightness) and the b^* component, (yellow) has appeared to be most relevant to changes in tooth color. This technique has provided an objective method to evaluate tooth color change. When coupled with subjective shade guide changes, results have been described both in objective and more clinically understood subjective form.

In most studies, only the maxillary anterior teeth were tested. The construction of a plastic jig for each subject to the spectrophotometer head at a fixed position relative to the tooth surface being evaluated have provided a more reproducible measurement. This technique is also being used in the current study as illustrated in following figures.



Figure 7. Jigs used to reproducibly place the chromameter head on the buccal surface of the maxillary right lateral, the maxillary left lateral and the maxillary central incisors.



Figure 8. Maxillary incisor jig with chromameter head in position for color measurement.
Risk mitigation

Past experience and institutional board review have agreed that risks to the subjects were minimal in these procedures. There have been reports of occasional transient hypersensitivity after the use of tooth whitening products with hydrogen peroxide. The sensitivity can occur in any of the teeth and typically lasts for a few days. All subjects were questioned post-treatment about sensitivity during and after treatment, and at recall visits. Extreme sensitivity experienced during the procedure was considered as basis for termination of the whitening procedure for that subject. In no case had this occurred. Palliative treatment in the form of fluoride gel application and desensitizing toothpaste were available to treat prolonged tooth sensitivity. In no case was this required.

Occasionally, individuals find it uncomfortable to have impressions of their teeth taken for fabrication of measurement jigs. However, none of the population in this study considered it a problem. It has been reported that some people may have found it difficult to sit and have the light and gel on their teeth for a full hour. This problem did not occur in this study.

Statistical Analysis

For each individual, values from the four maxillary incisors were evaluated for shade and measured using a Minolta CR 123 chromameter. Ordinal changes in shade guide values were calculated using the conversion defined in table 1.

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

Table 1. The numerical equivalent of the Vita® shade guide evaluations uses the manufacturers recommendations for ordering sequence. By this scale, B1 (lightest) = 1 and C4 (darkest)=16. Hence, larger shade guide values are darker.

Analytical method: Shade guide values were converted to numerical equivalents by values listed in table 1. Measured L^* , a^* and b^* values from chromameter measurements using fabricated stents were recorded. $\Delta E = \dots$ Values were computed from changes in the chromameter measurements (post-

$$\sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

treatment value – pre-treatment value). Each of these parameters was averaged across the four teeth in each subject and each subject average was used to evaluate change by analysis of covariance (ANCOVA). Overall tests for main effects were done by F test followed by between groups comparisons using least square means adjusted for the baseline covariate. By this analysis, the dependant variable was the average shade, L^* , a^* , b^* or ΔE value of each subject in a treatment group at the time point being evaluated. The covariate was the average pre-treatment value of each subject. Post-hoc evaluation was by Fisher's Least-Significant-Difference Test. Differences at pre-treatment in each parameter were evaluated by analysis of variance (ANOVA). Significance differences from pre-treatment were tested by a one-sample t-test of differences against an assumed mean value of 0. Analysis of questionnaire data was by chi-square and Fisher's exact test.

Subject population

Eighty-seven subjects (29 per group) completed the study with no dropouts. The age of the population was 40.8 ± 11.6 years (range 17-64 years). The population was 55.2% female (48) and 44.8% male and 87.4% white. No significant differences between experimental groups in these demographic variables were found.

Table 2. Age (years) of subjects participating in the study

Group	Mean	Standard Deviation	Minimum	Maximum
BriteSmile	42.3	12.3	19	61
Peroxide Control	39.9	11.8	17	58
Light Control	40.3	10.6	22	64
Average	40.8	11.6	17	64

Table 3. Gender of subjects participating in the study

Group	Female	Male
Peroxide + light	14	15
Peroxide Control	17	12
Light Control	17	12
Total	48	39

Table 4. Race of subjects participating in the study

Race	Frequency	Percent
Asian	3	3.4
Black	1	1.1
Hispanic	1	1.1
Unknown	6	6.9
White	76	87.4

All subjects had extremely good oral hygiene and were periodontally healthy as indicated by low plaque and gingival indices.

Table 5. Initial plaque index of subjects participating in the study

Group	Mean	Standard Deviation	Minimum	Maximum
Peroxide + light	0.08	0.14	0	0.5
Peroxide Control	0.17	0.28	0	1.0
Light Control	0.12	0.19	0	0.7

Table 6. Initial gingival index of subjects participating in the study

Group	Mean	Standard Deviation	Minimum	Maximum
Peroxide + light	0.73	0.28	0	1.2
Peroxide Control	0.69	0.26	0	1.0
Light Control	0.68	0.30	0	1.4

Primary Outcome (Shade Guide)

Initial shade change

The average change from pre- to post-therapy in shade guide increments of each group has been illustrated in the following figure.

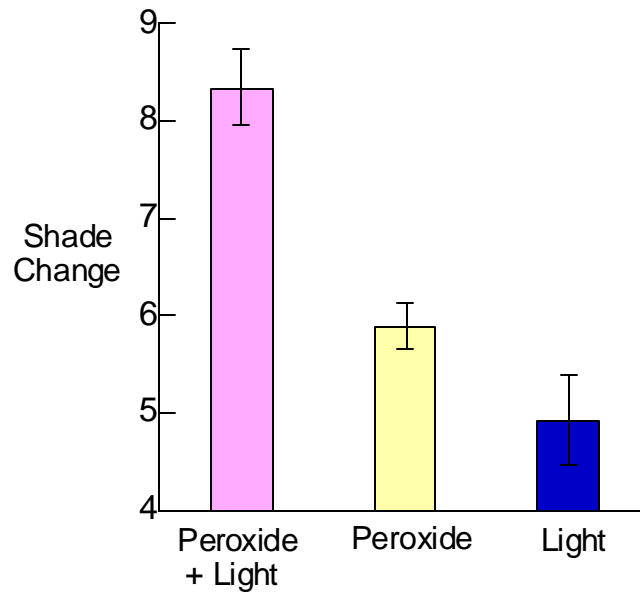


Figure 9. Initial average change in shade guide units (mean \pm SEM). Positive change represents change in the direction of tooth lightening. Peroxide + Light was the standard BriteSmile treatment. Peroxide was the response without light. Light was the response without peroxide. In this figure and all subsequent figures, each test was the average change of 4 teeth/subject (tooth numbers 7, 8, 9 and 10) over 29 subjects/group.

Table 7. Mean shade guide values at pre-treatment, post-treatment and mean changes (\pm S.D.).

Value	Peroxide + Light	Peroxide	Light
Pre-treatment	10.07	9.53	9.98
Post-treatment	1.72	3.65	5.05
Change	8.34 \pm 2.07	5.89 \pm 1.28	4.93 \pm 2.48

These data indicated that at pre-treatment teeth in each group were approximately D3 (10 on the shade guide series). Post-treatment, the peroxide + light treatment (BriteSmile) resulted in teeth that were approximately A1 (2 on the shade guide series). Peroxide treated teeth without the light resulted in teeth that were approximately D2 (4 on the shade guide series). Light treated teeth without peroxide were approximately A2 (5 on the shade guide series).

Range of shade change responses from pre- to post-treatment

Table 8. The pre-post-treatment median, maximum and minimum shade guide change increments for each treatment group has been summarized in the following table.

Value	Peroxide + Light	Peroxide	Light
Median	8	6	4.5
Maximum	13	8	9
Minimum	4	3.5	0



Figure 10. Tooth color change in subject 26 treated by peroxide + light (BriteSmile). The pre- to post treatment change was 13 shade guide units.

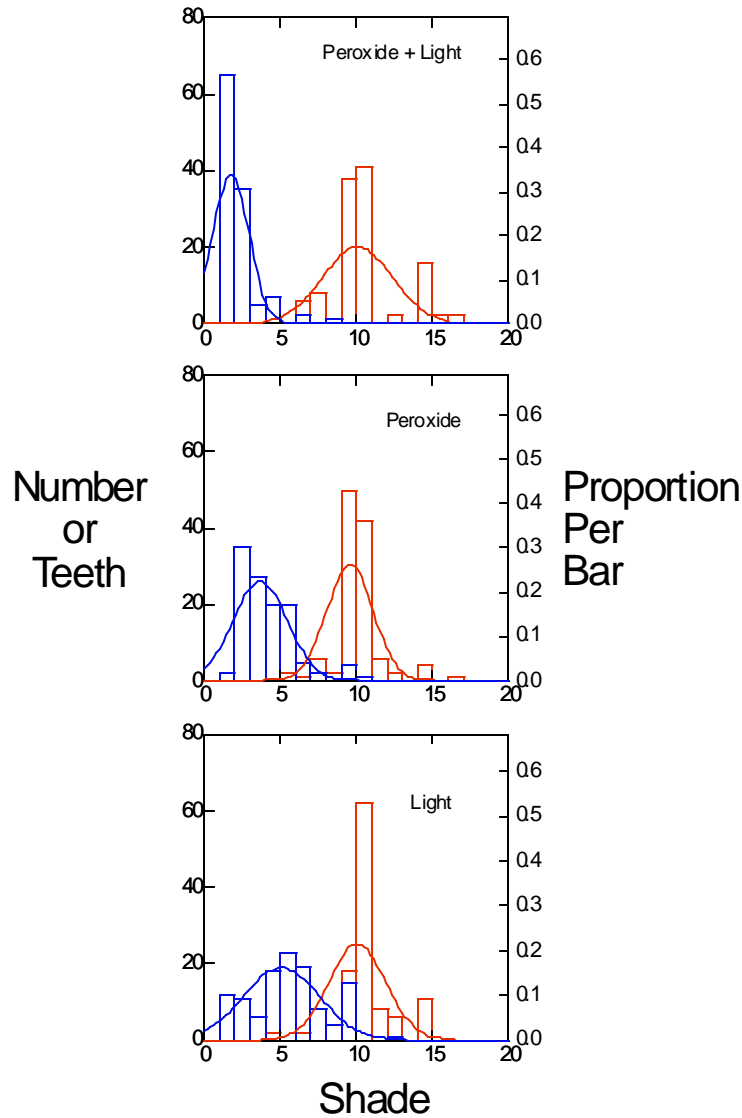


Figure 11. Distribution for all teeth of shade guide values of each treatment group before (red) and after (blue) therapy. Treatment by Peroxide + Light produced a large number of shades near the lightest value on the shade guide (1=B1). The peroxide and the light treatments produced much smaller changes.

These distributions indicate that all treatments produced a decrease in shade. The truncated Peroxide + Light distribution suggests that shade changes outside the range of the Vita shade guide had occurred as a result of this treatment.

Post-therapy Shade change

After the initial treatment, shades were evaluated at 3 and 6 months. These measurements have been summarized in the following figure.

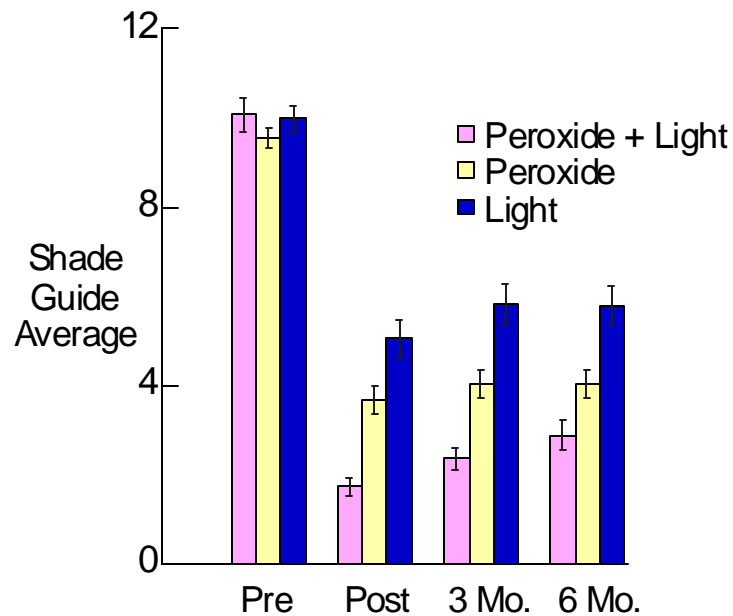


Figure 12. Average shade guide measurements over the 6-month observation period. Peroxide + Light maintained a 7.2 shade change at 6 months. Light alone and peroxide alone maintained a 4.2 and 5.5 shade change respectively at the 6-month observation period.

Table 9. Average shade guide measurement (\pm standard error of the mean for 29 subjects) at each observation period.

Treatment	Pre-treatment	Post-treatment	3 Months	6 Months
Peroxide and Light	10.07 \pm 0.39	1.72 \pm 0.20	2.35 \pm 0.23	2.89 \pm 0.34
Peroxide	9.53 \pm 0.23	3.65 \pm 0.31	4.03 \pm 0.33	4.04 \pm 0.33
Light	9.98 \pm 0.29	5.05 \pm 0.44	5.83 \pm 0.44	5.78 \pm 0.43

Statistical analysis of change in tooth Shade

Significance levels of average shade values at pre-treatment. The probability of the overall ANOVA F-test for treatment effect was 0.4 indicating that no significant changes between groups existed at pre-treatment.

Table 10. Significance levels of average change in shade values from pre- to post-treatment. The probability of the overall ANCOVA F-test for treatment effect was < 0.0001 indicating that significant changes between groups existed at post-treatment. Pair wise comparison indicated that the peroxide + light treatment produced a greater reduction in shade value than either the peroxide or light controls. The difference between peroxide and light alone treatments was also statistically significant.

	Peroxide + Light	Peroxide
Peroxide	0.0001*	
Light	0.0001*	0.007*

* Significant, $p < 0.05$

These data indicated that immediately following treatment, the peroxide + light treatment group had significantly greater shade reducing effect than either of the control group treatments. The peroxide alone treatment was significantly more effective than the light alone treatment.

Table 11. Significance levels of average change in tooth shade values from pre-treatment to 3 months. The probability of the overall ANCOVA F-test for treatment effect was < 0.0001 indicating that significant changes between groups existed at 3 months. Pair wise comparison indicated that the same relationships seen in the immediate pre-post treatment comparisons were preserved.

	Peroxide + Light	Peroxide
Peroxide	0.0001*	
Light	0.0001*	0.001*

* Significant, $p < 0.05$

Table 12. Significance levels of average change in tooth shade values from pre-treatment to 6 months. The probability of the overall ANCOVA F-test for treatment effect was < 0.0001 indicating that changes between groups at 6 months were borderline in statistical significance. Pair wise comparison indicated that the same relationships seen in the immediate pre-post treatment comparisons were preserved.

	Peroxide + Light	Peroxide
Peroxide	0.001*	
Light	0.0001*	0.002*

* Significant, $p < 0.05$

These data indicate that by shade guide analysis, the reduction in shade following the peroxide + light treatment was significantly greater than either peroxide or light when evaluated immediately following treatment, at 3 months and at 6 months following initial treatment.

Estimated duration of shade reduction by peroxide + light treatment

The estimated duration of the shade reduction by peroxide + light treatment was estimated by linear regression of the percent of effect over the time measured. The results of this computation have been illustrated in the following figure.

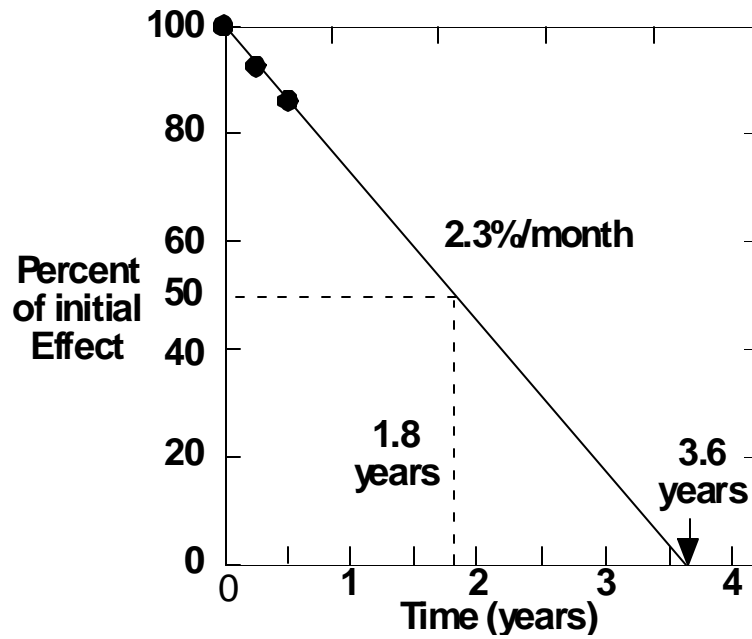


Figure 13. Based on an average effect of 8.34 shade units reduction by the peroxide + light treatment, 92.4% (7.71 shade units) was maintained at 3 months and 86.1% (7.18 shade units) was maintained at 6 months.

By linear regression, the effect appears to be decreasing at an approximately linear rate of 2.3%/month. This suggests tooth lightning using the peroxide + light treatment has an average half time of 1.8 years and a total duration of effect of 3.6 years.

Primary Outcome (Chromameter)
Initial shade change

△L* values

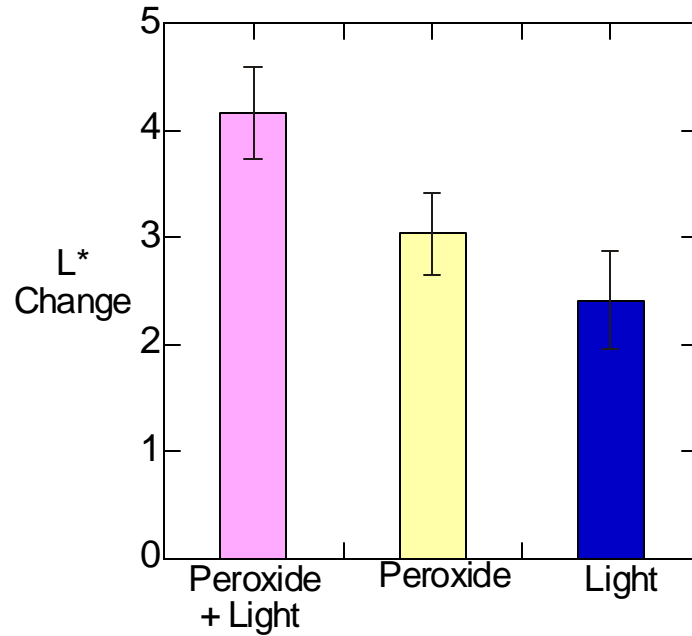


Figure 14. Average change in lightness (L*) units (mean \pm Standard error) from pre-to post-therapy. Positive values of L* are white (see table below). Change (post-treatment minus pre-treatment) is positive for a change toward increased whiteness.

Table 13. Mean L* values at pre-treatment, post-treatment and mean changes (\pm S.D.).

Value	Peroxide + Light	Peroxide	Light
Pre-treatment	50.48	50.27	50.54
Post-treatment	54.65	53.30	52.95
Change	4.17 \pm 2.32	3.03 \pm 2.05	2.41 \pm 2.46

Post-therapy change in L*

After the initial treatment, L* was evaluated at 3 and 6 months. These measurements are summarized in the following figure.

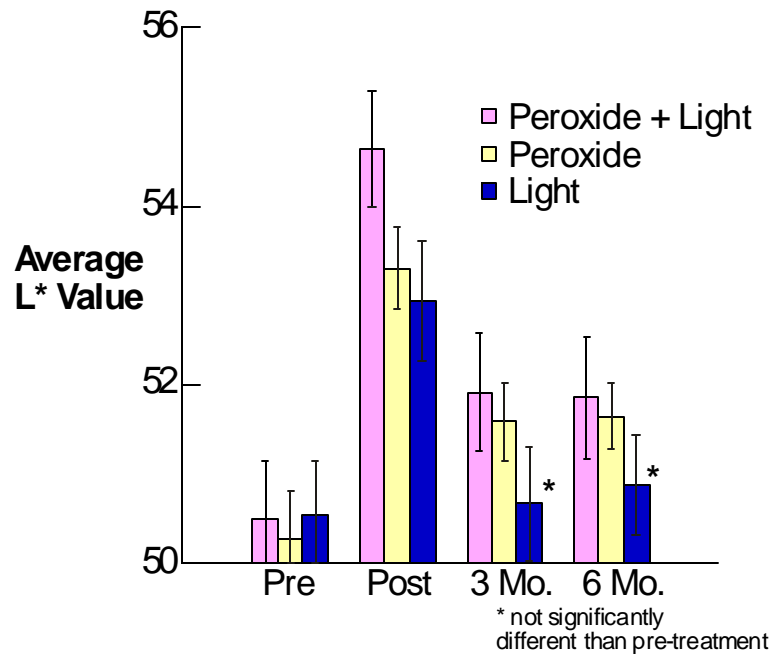


Figure 15. Average L* measurements over the 6 month observation period. Peroxide + Light and peroxide alone maintained an L* greater than at pre-therapy at 6 months. The L* measurement of the light alone group was not different from pre-treatment at the 3 and 6 month observation periods.

Table 14. Average L* measurement (\pm standard error of the mean for 29 subjects) at each observation period.

Treatment	Pre-treatment	Post-treatment	3 Months	6 Months
Peroxide and Light	50.48 \pm 0.65	54.64 \pm 0.66	51.91 \pm 0.66	51.85 \pm 0.69
Peroxide	50.27 \pm 0.53	53.30 \pm 0.45	51.58 \pm 0.44	51.64 \pm 0.38
Light	50.54 \pm 0.59	55.95 \pm 0.67	50.66 \pm 0.64	50.87 \pm 0.56

Statistical analysis of change in L*

Interpretation: The L* parameter measures the colors white (positive) to black (negative). All teeth had large positive values for L*. Increasing positive values of L* are interpreted as increases in whiteness. Decreasing positive values have been interpreted as loss of whiteness.

Significance levels of at pre-treatment average L values:* The probability of the overall ANOVA F-test for treatment effect was 0.9 indicating that no significant changes between groups existed at pre-treatment.

Significance levels of post-treatment average L values:* The increase in whiteness as measured by the L* parameter was positive for all treatments. The peroxide + light treatment significantly increased whiteness to a greater level than the light control at every measurement visit. The incremental whiteness increase of the peroxide + light treatment group was not significantly greater than that of the peroxide control group at 3 and 6 months.

Table 15. Significance levels of average change in L* values from pre- to post-treatment. The probability of the overall ANCOVA F-test for treatment effect was 0.01, 0.02 and 0.06 respectively for the immediate pretreatment, 3 month and 6 month visits. This indicates that significant differences between groups existed up to 3 months and borderline significant differences existed at 6 months. Pair wise comparisons indicated that the peroxide + light treatment produced a greater increase in whiteness than the light control group at every visit and a greater increase in whiteness than the peroxide group at the immediate post-therapy visit. The difference between peroxide alone and light alone treatments was statistically significant only at the 3-month visit.

		Peroxide + Light	Peroxide
Pre- vs. Post-treatment (immediate)	Peroxide	0.04*	
	Light	0.003*	0.33
		Peroxide + Light	Peroxide
Pre- vs. 3 months	Peroxide	0.75	
	Light	0.01*	0.02*
		Peroxide + Light	Peroxide
Pre – vs. 6 months	Peroxide	0.73	
	Light	0.03*	0.06

* Significant, p<0.05

Δa^* values

As indicated in the following figure and table, changes in the a^* parameter were extremely small.

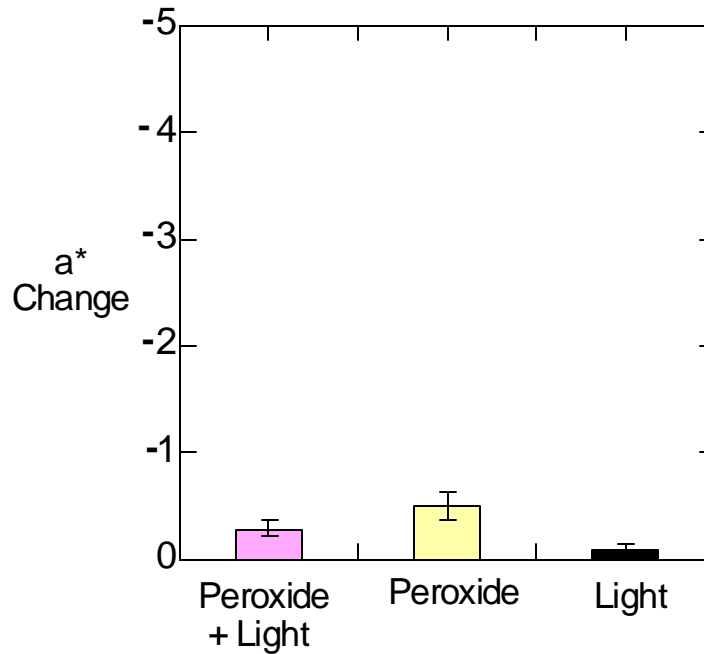


Figure 16. Average change in a^* units (Δa^*) (mean \pm SEM).

The small negative values of a^* (see following table) have represented a light green color in a principally gray portion of the spectrum ($a^* = 0$ is gray). Change (Post-treatment minus pre-treatment) was negative for a change toward increased greenness (or decreased grayness). This parameter was very small and contributed only slightly to the tooth color.

Table 16. Pre-treatment, post-treatment and changes (mean \pm S.D.) in the a^* parameter.

Value	Peroxide + Light	Peroxide	Light
Pre-treatment	-1.81	-2.04	-2.00
Post-treatment	-2.10	-2.55	-2.08
Change	-0.29 \pm 0.44	-0.51 \pm 0.70	-0.08 \pm 0.32

Post-therapy change in a^*

After the initial treatment, a^* was evaluated at 3 and 6 months. These measurements have been summarized in the following figure.

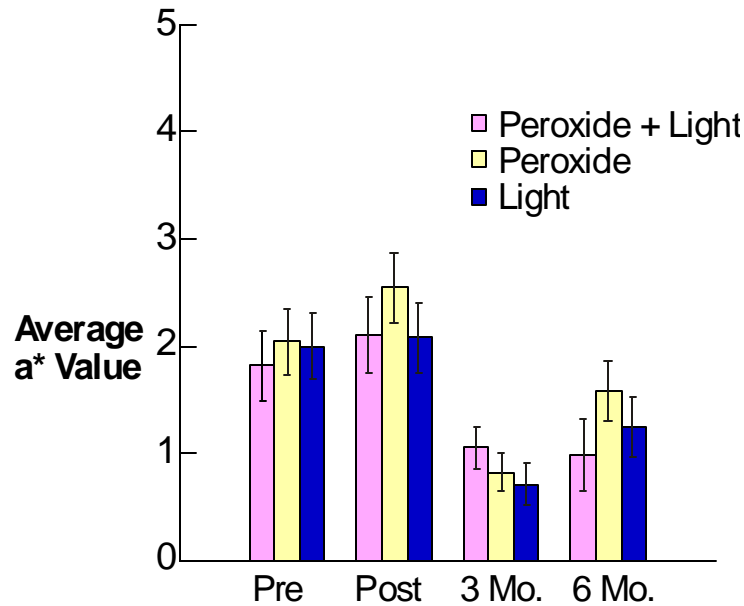


Figure 17. Average a* measurements over the 6-month observation period. Changes and differences in the a* parameter were generally less than 1 unit and did not contribute substantially to color characterization.

Table 17. Average a* measurement (\pm standard error of the mean for 29 subjects) at each observation period.

Treatment	Pre-treatment	Post-treatment	3 Months	6 Months
Peroxiside and Light	-1.81 \pm 0.33	-2.10 \pm 0.36	-1.05 \pm 0.20	-0.98 \pm 0.34
Peroxiside	-2.04 \pm 0.31	-2.55 \pm 0.33	-0.82 \pm 0.17	-1.58 \pm 0.28
Light	-2.00 \pm 0.31	-2.08 \pm 0.32	-0.71 \pm 0.19	-1.25 \pm 0.28

Statistical analysis of change in a*

Interpretation. The a* parameter measures the colors red (positive) to green (negative). All teeth had a small negative value for a* suggesting a slight green hue. Smaller absolute values of a* would suggest a reduction in greenness. Since neither green nor red are prominent in tooth coloration, it might be expected that this parameter might play a minor role in evaluation of tooth color changes.

Significance levels of at pre-treatment average a values:* The probability of the overall ANOVA F-test for treatment effect was 0.86, indicating that, no significant differences between groups existed between treatment groups prior to therapy.

Significance levels of post-treatment average a values:* Average changes in a* values from pre- to post-treatment were generally not statistically significant. The probability of the overall ANCOVA F-test was 0.008, 0.46 and 0.38 for immediate post-treatment, 3 month and 6 month analysis respectively, indicating that, with the exception of a transient effect at the immediate post-treatment period, no significant changes between groups existed at any pretreatment visit.

Table 18. Significance levels of average change in a* values from pre- to post-treatment. The colors represented by the a* parameter (red to green) were not significantly associated with tooth color. From

an operational standpoint, this simplifies the analytical aspects of tooth color measurement by focusing on increases in the L* parameter (whiteness) and decreases in the b* parameter (yellowness).

		Peroxide + Light	Peroxide
Pre- vs Post-treatment (immediate)			
	Peroxide	0.12	
	Light	0.12	0.002*
		Peroxide + Light	Peroxide
Pre- vs. 3 months			
	Peroxide	0.42	
	Light	0.23	0.69
		Peroxide + Light	Peroxide
Pre - vs. 6 months			
	Peroxide	0.17	
	Light	0.58	0.41

* Significant, $p < 0.05$

Δb^* values

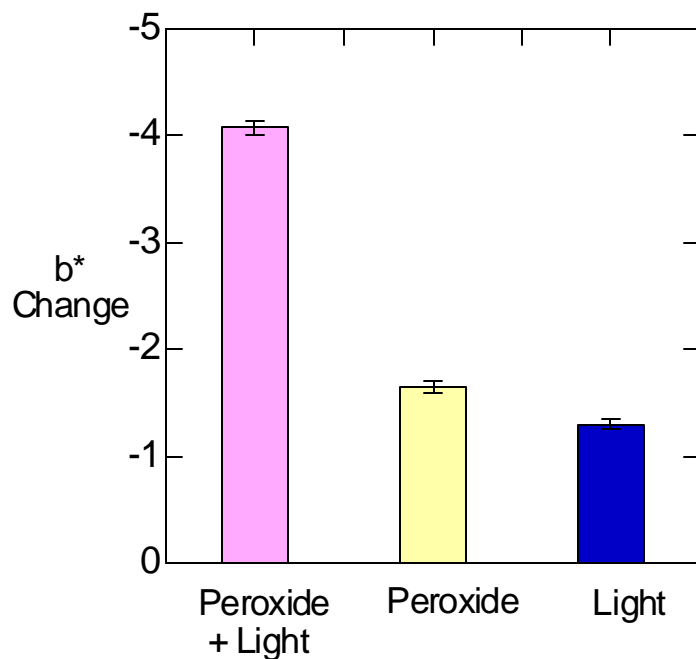


Figure 18. The average change in yellowness (mean $\Delta b^* \pm$ SEM). A positive value of b^* is yellow. The change (Post-treatment minus pre-treatment) is negative for yellowness reduction.

Table 19. Mean values at pre-treatment, post-treatment and mean changes (+ S.D.) in the b^* parameter.

Value	Peroxide + Light	Peroxide	Light
Pre-treatment	5.25	5.52	5.11
Post-treatment	1.90	4.01	3.91
Change	-3.36 ± 1.5	-1.51 ± 1.1	-1.20 ± 1.04

Post-therapy change in b*

After the initial treatment, b* was evaluated at 3 and 6 months. These measurements were summarized in the following figure.

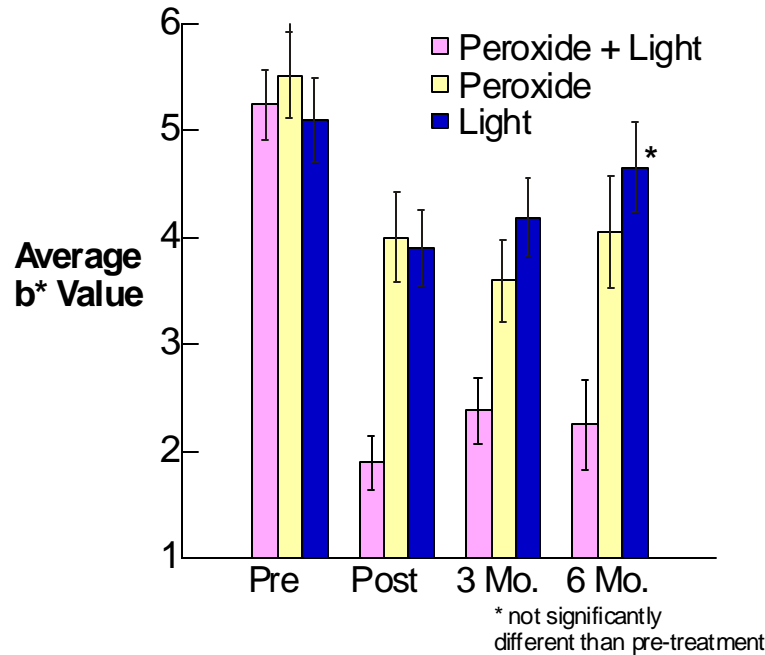


Figure 19. Average b* measurements over the 6 month observation period. Peroxide + Light and peroxide alone maintained a b* lower than at pre-therapy at 6 months. The b* measurement of the light alone group was not different from pre-treatment at the 6 month observation period.

Table 20. Average b* measurement (± standard error of the mean for 29 subjects) at each observation period.

Treatment	Pre-treatment	Post-treatment	3 Months	6 Months
Peroxide and Light	5.25 ± 0.33	1.90 ± 0.25	2.39 ± 0.31	2.25 ± 0.42
Peroxide	5.52 ± 0.40	4.01 ± 0.42	3.61 ± 0.38	4.06 ± 0.53
Light	5.11 ± 0.39	3.91 ± 0.36	4.19 ± 0.36	4.66 ± 0.42

Statistical analysis of change in b*

Interpretation: The b* parameter measures the colors yellow (positive) to blue (negative). All teeth appear slightly yellow and have positive b* values. A reduction in b* values (post-therapy minus pre-therapy) is negative for a reduction in tooth yellowness associated with the b* parameter.

Significance levels of pre-treatment average b values:* The probability of the overall ANOVA F-test for treatment effect was 0.7 indicating that no significant differences between groups existed between treatment groups prior to therapy.

Significance levels of post-treatment average b values:* The reduction in yellowness as measured by a decrease in the b* parameter was the greatest and statistically most powerful changes measured using the chromameter in association with tooth bleaching procedures. The peroxide + light treatment significantly decreased yellowness to a greater level than any of the controls at every measurement visit.

Table 21. Significance levels of average change in b* values from pre- to post-treatment. The probability of the overall ANCOVA F-test for treatment effect was < 0.0001 at each visit indicating that significant differences between groups existed at all post-treatment visits. Pair wise comparisons indicated that the peroxide + light treatment produced a greater decrease in yellowness than either the peroxide or light controls at every visit. The difference between peroxide and light alone treatments was not statistically significant except at the 6-month visit.

		Peroxide + Light	Peroxide
Pre- vs. Post-treatment (Immediate)	Peroxide	0.0001*	
	Light	0.0001*	0.51
		Peroxide + Light	Peroxide
Pre- vs. 3 months	Peroxide	0.01*	
	Light	0.0001*	0.065
		Peroxide + Light	Peroxide
Pre – vs. 6 months	Peroxide	0.0001*	
	Light	0.0001*	0.04*

* Significant, p<0.05

ΔE* values

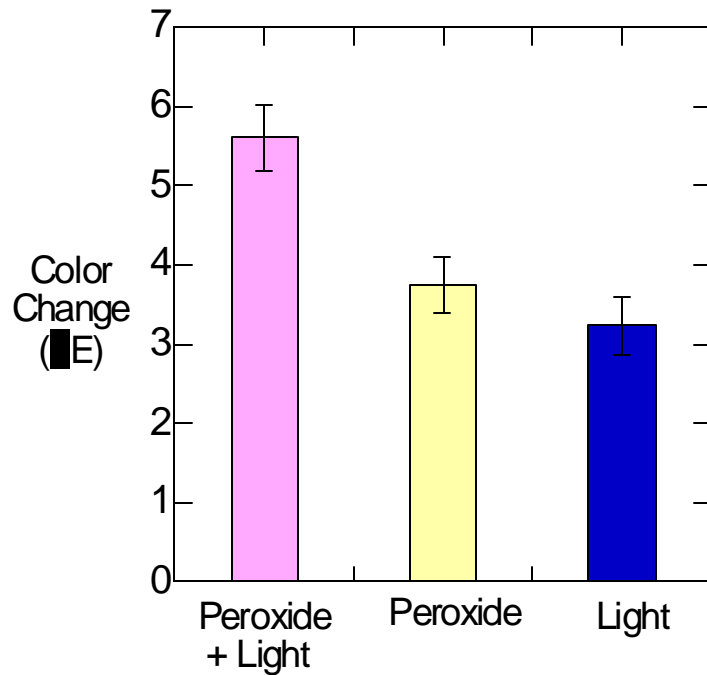


Figure 20. Average total color change (ΔE) (mean \pm SEM). Although all treatments changed tooth color, the total tooth color change resulting from peroxide + light (BriteSmile therapy) has appeared to be much greater than either the peroxide or light control.

Table 22. Mean ΔE values (\pm S.D.).

Value	Peroxide + Light	Peroxide	Light
Change	5.62 ± 2.24	3.75 ± 1.91	3.24 ± 1.98

Analysis by ANOVA has indicated that significant differences in mean color change (ΔE) values between groups occurred ($F=10.9$, $p=0.0001$). Color change in the peroxide + light group was significantly greater than either peroxide or light controls (Table 24). The peroxide and light controls were not significantly different from each other. This indicates that the peroxide + light treatment had significantly greater effect on total color change than either of the peroxide or the light control group treatments. In contrast, the total color change of the peroxide and light controls did not significantly differ from each other.

Post-therapy change in ΔE

After the initial treatment, ΔE was evaluated at 3 and 6 months. These measurements are summarized in the following figure.

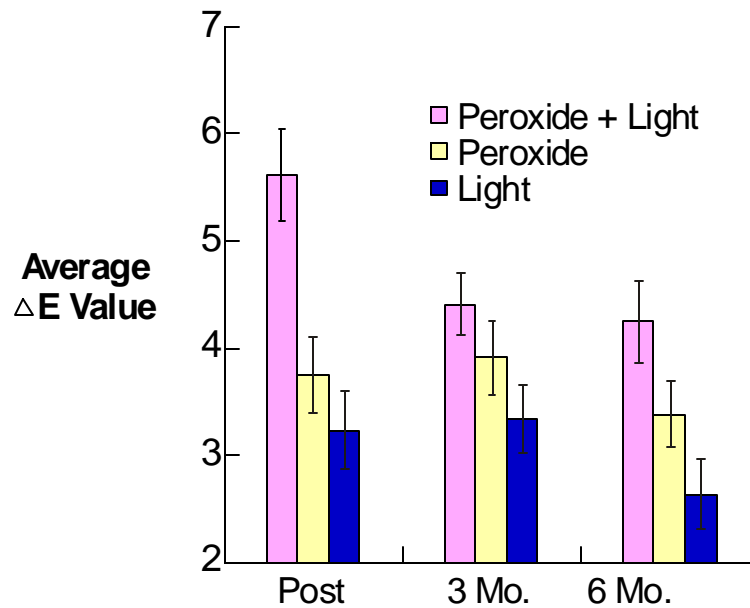


Figure 21. Average ΔE measurements over the 6-month observation period. Peroxide + Light maintained a ΔE higher than either control through 6 months.

Table 23. Average ΔE measurement (\pm standard error of the mean for 29 subjects) at each observation period.

Treatment	Post-treatment	3 Months	6 Months
Peroxide and Light	5.62 \pm 0.42	4.41 \pm 0.30	4.24 \pm 0.38
Peroxide	3.75 \pm 0.35	3.91 \pm 0.35	3.37 \pm 0.31
Light	3.24 \pm 0.37	3.34 \pm 0.32	2.63 \pm 0.33

Statistical analysis of change in ΔE *

Interpretation: The ΔE parameter is a derived measure that evaluates the total tooth color change. If $\Delta E=0$, there is no color change. Larger ΔE values indicate larger color change.

Significance levels of post-treatment average ΔE values: The color change as measured by an increase in the ΔE parameter was significantly greater for the peroxide + light treatment than the light control at every measurement visit. The difference between the peroxide + light treatment group and the peroxide alone group was significant only at the immediate post-treatment period.

Table 24. Significance levels of average change in ΔE values from pre- to post-treatment. The probability of the overall ANCOVA F-test for treatment effect was < 0.0001 , 0.07 , and 0.005 at the immediate post-treatment measurement, the 3month visit and the 6month visit respectively. This indicates that significant differences between groups existed through 6 months. Pair wise comparisons indicated that the peroxide + light treatment produced a greater color change than the light controls at every visit. The peroxide + light treatment was different than the peroxide control only at the immediate post-treatment visit. The difference between peroxide and light alone treatments was not statistically significant at any visit.

		Peroxide + Light	Peroxide
Pre- vs. Post-treatment (immediate)	Peroxide	0.0001*	
	Light	0.001*	0.35
		Peroxide + Light	Peroxide
Pre- vs. 3 months	Peroxide	0.28	
	Light	0.02*	0.21
		Peroxide + Light	Peroxide
Pre – vs. 6 months	Peroxide	0.08	
	Light	0.001*	0.13

* Significant, $p < 0.05$

Gingival Index and Plaque Index

The gingival and plaque indices were recorded at the baseline, 3 months and 6 months visits. Gingival index was recorded to provide an indication of potential gingival irritation that could be associated with the tooth whitening procedures. Plaque index was recorded as a measure of the subject's home care effectiveness. Both measures were recorded for all teeth and averaged to provide a subject estimate. The average across all subjects is recorded in the following table.

Table 25. Mean gingival and plaque indices (+ SD)

Gingival Index	Baseline	3 Months	6 Months
Treatment:			
Peroxide + Light	0.64 ± 0.29	0.33 ± 0.34	0.28 ± 0.30
Peroxide	0.65 ± 0.37	0.44 ± 0.32	0.39 ± 0.37
Light	0.70 ± 0.31	0.49 ± 0.31	0.55 ± 0.36
Plaque Index			
Peroxide + Light	0.15 ± 0.28	0.16 ± 0.30	0.18 ± 0.30
Peroxide	0.11 ± 0.20	0.11 ± 0.21	0.14 ± 0.30
Light	0.05 ± 0.12	0.16 ± 0.26	0.14 ± 0.19

Gingival Index

The gingival index data is illustrated in the following figure.

Figure 22. Average Gingival Index measurements over the 6-month observation period. Peroxide + Light maintained a lower gingival index than either control through 6 months.

The gingival index was measured by the method of Loe and Silness (1963) and is described as follows:

- 0 = Normal gingiva.
- 1 = Mild; slight color change; slight edema.
- 2 = Moderate; Redness and Glazing.
- 3 = Severe; Marked redness and edema; ulceration; spontaneous bleeding.

These data indicate that all subjects had an extremely low gingival index before the tooth whitening procedure indicating that they generally had healthy gums before the whitening procedures were administered. Following the treatment, however, the gingival index was reduced to a greater level than before treatment in all groups. By the 6-month observation period, the peroxide + light treatment remained at lowered levels which were significantly lower than that of the light control treated group. These data indicate that no irritant effect as measured by the gingival index was observed in this study. Statistical analysis of change in Gingival Index

Analysis of the gingival index data by analysis of covariance revealed that 3-month values of the three groups were not significantly different whereas the peroxide + light group was significantly lower than the light control group at 6 months.

Table 26. Significance levels for ANCOVA of 6-month gingival index data.

Overall F-test of 6-Month difference for treatment effect: 0.0137			
	Peroxide + Light	Peroxide	Light
Peroxide + Light	.	0.2291	0.0037*
Peroxide	0.2291	.	0.0822
Light	0.0037*	0.0822	.

*Significant $p < 0.05$

Plaque Index

The gingival index data is illustrated in the following figure.

Figure 23. Average plaque index measurements over the 6-month observation period. No differences between groups are apparent.

The plaque index of Silness and Loe (1964) is defined as:

- 0 = No plaque.
- 1 = Film at gingival margin: remove plaque with probe.
- 2 = Moderate; seen with naked eye.
- 3 = Abundance of material.

Clearly, these subjects had excellent home care at the pre-treatment visit and maintained excellent home care throughout the 6-month monitoring period. No statistically significant between group differences were found.

Intraoral examination

Examination

Oral tissues were examined by a dentist after treatment procedures were completed. The form used for recording these observations is as follows:

		Soft and Hard Tissue Examination	
Area		Normal	
1. Soft Palate		Yes	No
2. Hard Palate		Yes	No
3. Gingival Mucosa		Yes	No
4. Buccal Mucosa		Yes	No
5. Mucogingival Folds		Yes	No
6. Tongue		Yes	No
7. Sublingual and submandibular areas		Yes	No
8. Salivary Glands		Yes	No
9. Tonsillar and pharyngeal areas		Yes	No
10. Teeth		Yes	No

If any of the questions 1-10 is NO, please explain.

Immediate post-therapy Results

Records are available for 98.8% (86) subjects participating in the study.

Table 27. Responses recorded at the time of post-therapy intraoral examination. A dentist has conducted the examination within a few minutes of treatment completion.

Question	% Considered not normal after therapy
1 Soft Palate	0%
2 Hard Palate	0%
3 Gingival Mucosa	11.6% (10 subjects)
4 Buccal Mucosa	0%
5 Mucogingival Folds	0%
6 Tongue	0%
7 Sublingual and submandibular areas	1.2% (1 subject)
8 Salivary Glands	0%
9 Tonsillar and pharyngeal areas	0%
10 Teeth	11.6% (10 subjects)

Exam 3. Gingival mucosa

Table 28. Responses recorded at the time of post-therapy intraoral examination of gingival mucosa.

Subject	Treatment	Explanation
40	Light	Redness above 7,8,9
66	Light	Redness at gingival margin of 7-10
3	Peroxide + Light	A tiny bit of redness on upper and lower
4	Peroxide + Light	Slight redness from tooth #19 /tooth #12
22	Peroxide + Light	7-10 slightly red, 27-22 slightly red, lip lower
47	Peroxide + Light	Slight redness above #8
83	Peroxide + Light	Redness slight from 6-11
87	Peroxide + Light	Slight redness above 7-10

41	Peroxide	Redness between 7 & 8
44	Peroxide	Redness at margins on #8

All changes in gingival mucosa noted were slight increases in gingival redness. These occurred at low frequencies in all three-treatment groups. The observed frequency of redness at the gingival margin was higher in subjects treated by peroxide + light (21%) than either of the control groups (7%).

Exam 7. Sublingual and submandibular areas

Table 29. Responses recorded at the time of post-therapy intraoral examination of sublingual and submandibular areas.

Subject	Treatment	Explanation
65	Peroxide	Left upper lip is red and slightly sore at edges

The only change in the perioral areas was one instance of lip redness and soreness noted in a peroxide control subject. On the immediate post-treatment questionnaire, this subject rated discomfort as moderate. At the one-week follow-up questionnaire, this subject indicated there was no pain associated with his lips.

Exam 10. Teeth

Table 30. Responses of the 10 subjects who were identified as having identifiable changes in tooth characteristics recorded at the time of post-therapy intraoral examination.

Subject	Treatment	Explanation
45	Light	#14 aches and ached during procedure
42	Peroxide + Light	#7 has slight pain
50	Peroxide + Light	Swollen red area-middle of upper lip. Sensitivity on lower and some upper in the last 10 minutes
60	Peroxide + Light	Slight sensitivity – lower anterior “burned”, sensation, lower right lip appears red and cracked
61	Peroxide + Light	Slightly sensitive on lower anterior teeth
71	Peroxide + Light	Tooth #22 had slight pain
74	Peroxide + Light	Tingles on lower anteriors and upper left anterior at the end of procedure
76	Peroxide + Light	Upper anterior has slight sensitivity
79	Peroxide + Light	Lower anterior has slight pain
29	Peroxide	Tooth # 10 has slight sensitivity

Eight of 31 subjects treated with peroxide + light (27.6 %) were verified to have some tooth sensitivity at the end of the treatment period. One of 29 subjects treated with either light alone or peroxide alone had similar effects.

3-Month Results

Table 31. 3-month results of intra-oral examination

Question	% Considered normal after 3 months	not Subject #(Treatment)
1 Soft Palate	0%	
2 Hard Palate	1.2% (1 subject)	68(Peroxide + light)
3 Gingival Mucosa	11.6% (2 subjects)	41(Peroxide) 47(Peroxide + light)
4 Buccal Mucosa	0%	
5 Mucogingival Folds	0%	
6 Tongue	0%	
7 Sublingual and submandibular areas	0%	
8 Salivary Glands	0%	
9 Tonsillar and pharyngeal areas	0%	
10 Teeth	0%	

6-Month Results

Table 31. 6-month results of intra-oral examination

Question	% Considered normal after 6 months	not Subject #(Treatment)
1 Soft Palate	0%	
2 Hard Palate	0%	
3 Gingival Mucosa	3.5% (3 subjects)	48(peroxide) 69(light) 77(light)
4 Buccal Mucosa	1.2% (1 subject)	18(peroxide)
5 Mucogingival Folds	0%	
6 Tongue	1.2% (1 subject)	19(peroxide + light)
7 Sublingual and submandibular areas	0%	
8 Salivary Glands	0%	
9 Tonsillar and pharyngeal areas	0%	
10 Teeth	1.2% (1 subject)	26(peroxide + light)

None of the intraoral examination results revealed a statistically significant trend and observations after the immediate post-treatment visit appeared to be no greater than that one would expect in a normal healthy subject population.

Questionnaire Responses

Post-treatment Questionnaire

1. How much did the product increase the whiteness of your teeth?
Not at all Slightly Moderately Greatly
2. Did the test product reduce the yellowness of your teeth?
Not at all Slightly Moderately Greatly
3. Did you feel any discomfort during the procedure?
Not at all Slightly Moderately Greatly
If yes, please explain _____
4. Did your teeth feel sensitive before the procedure?
Not at all Slightly Moderately Greatly
5. Did your teeth feel sensitive after the procedure?
Not at all Slightly Moderately Greatly
6. Would you recommend this procedure to your friends?
Not at all May be Yes

1. How much did the product increase the whiteness of your teeth?

Table 32. Question 1 responses, post-treatment questionnaire.

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	0 (0.0%)	1 (3.4%)	8 (27.6%)	20(69.0%)
Peroxide	7 (25.0%)	10(35.7%)	10(35.7%)	1 (3.6%)
Light	1 (3.6%)	12(42.9%)	9 (32.1%)	6 (21.4%)

These differences were highly significant ($p < 0.001$). Everyone treated by the peroxide + light treatment recognized an increase in whiteness (not at all = 0%) and over 2/3 recognized a great change (greatly = 69%). Only one subject in this group categorized the whiteness change as "slight". Interestingly, this subject (#19) went from a shade of 9 (A3) to 2 (A1), or a 7-shade tab change from pre- to post-therapy.

Table 33. Question 1 response, post-treatment questionnaire pooled.

Treatment	None-slightly	Moderately-Greatly
Peroxide-light	1	28 (96.6%)
Peroxide	17	11 (39.3%)
Light	13	15 (53.6%)

These data indicate that differences in subject perception of tooth whitening between treatments were statistically significant ($p < 0.001$) with 96.6% of the peroxide-light treated group recognizing a moderate to great increase in whiteness.

2. Did the test product reduce the yellowness of your teeth?

Table 34. Question 2 responses, post-treatment questionnaire.

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	0 (0.0%)	2 (6.9%)	7 (24.1%)	20(69.0%)
Peroxide	7 (25.0%)	7 (25.0%)	13(46.4%)	1 (3.6%)
Light	1 (3.4%)	13(44.8%)	9 (31.0%)	6 (20.7%)

These differences were highly significant ($p < 0.001$).

Table 35. Question 2 responses, post-treatment questionnaire-pooled.

Treatment	None-slightly	Moderately-Greatly
Peroxide-light	2	27 (93.1%)
Peroxide	14	14 (50.0%)
Light	14	15 (51.7%)

Differences in subject perception of reduction in tooth yellowness between treatments were statistically significant ($p=0.001$). Almost all subjects treated by peroxide + light recognized a decrease in yellowness (93.1% moderate to great). The two subjects treated by peroxide + light categorizing the reduction in yellowness as "slight" (#19 and 43) had a reduction in the b^* parameter that measures yellowness of 3.81 units compared with the group mean reduction of 3.36 units.

3. Did you feel any discomfort during the procedure?

Table 36. Question 3 responses, post-treatment questionnaire.

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	5 (17.2%)	19(65.5%)	5 (6.9%)	0 (0.0%)
Peroxide	14(48.3%)	12(41.3%)	3(10.3%)	0 (0.0%)
Light	10(34.5%)	16(55.2%)	2 (6.9%)	1 (3.4%)

$P = 0.16$

Table 37. Question 3 responses, post-treatment questionnaire-pooled.

Treatment	None-slightly	Moderately-Greatly
Peroxide-light	24	5 (17.24%)
Peroxide	26	3 (10.34%)
Light	26	3 (10.34%)

Differences in subject perception of discomfort between treatments were not statistically significant ($p=0.66$).

4. Did your teeth feel sensitive before the procedure?

Table 38. Question 5 responses, post-treatment questionnaire.

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	28(96.6%)	1 (3.4%)	0 (0.0%)	0 (0.0%)
Peroxide	26(89.7%)	3(10.3%)	0 (0.0%)	0 (0.0%)
Light	27(96.4%)	1 (3.6%)	0 (0.0%)	0 (0.0%)

Table 39. Question 4 responses, post-treatment questionnaire.

Treatment	None-slightly	Moderately-Greatly
Peroxide-light	29	0 (0.0%)
Peroxide	29	0 (0.0%)
Light	28	0 (0.0%)

None of the subjects noted tooth sensitivity before the procedure.

5. Did your teeth feel sensitive after the procedure?

Table 40. Question 5 responses, post-treatment questionnaire.

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	15(51.7%)	10(34.5%)	3 (10.3%)	1 (3.4%)
Peroxide	25(86.2%)	3(10.3%)	1(3.4%)	0 (0.0%)
Light	27(93.1%)	2(6.9%)	0 (0.0%)	0 (0.0%)

P = 0.01

Table 41. Question 5 responses, post-treatment questionnaire-pooled.

Treatment	None-slight	Moderately-Great
Peroxide-light	25	4 (13.8%)
Peroxide	28	1 (3.5%)
Light	29	0 (0.0%)

Differences in subject perception of tooth sensitivity between treatments after the treatment procedure were not statistically significant ($p=0.12$, Fisher's exact test). If, however, one compares the group as a whole with their response to question 4 (did they have prior sensitivity), a significant increase in tooth sensitivity is noted.

Table 42. Question 5 responses relative to question 4, post-treatment questionnaire.

Question	None-slight	Moderately-Great
4(sensitivity before)	86(100.0%)	0 (0.0%)
5(sensitivity after)	82 (94.3%)	5 (5.7%)

P=0.02

6. Would you recommend this procedure to your friends?

Table 43. Question 6 responses, post-treatment questionnaire.

Treatment	No	Maybe	Yes
Peroxide-light	0	8 (27.6%)	21 (72.4%)
Peroxide	4 (14.3%)	6 (21.4%)	18 (64.3%)
Light	0	14 (48.3%)	15 (51.7%)

Differences in subject willingness to recommend treatments to friends after the treatment procedure were statistically significant ($p=0.01$). All subjects treated by peroxide + light or by the light alone would have at least considered recommending it to their friends.

One-week follow-up Questionnaire

- How would you rate your overall experience with the whitening procedure?
Excellent Very Good Good Fair Poor
- Compared to your appearance immediately after the treatment, do you think that the whiteness of your teeth has decreased?
Not at all Slightly Moderately Greatly
- Compared to your appearance immediately after the treatment, do you think that the yellowness of your teeth has increased?
Not at all Slightly Moderately Greatly
- Have your teeth been more sensitive after the procedure?
Not at all Slightly Moderately Greatly
- Did you take Advil, Tylenol, aspirin, or any pain relief medications in order to relieve tooth sensitivity at any time after the procedure?
Yes No
- Please tell us if you experienced sensitivity or discomfort in any other parts of your mouth, as listed below.

a)Lips	Yes	No	
b)Gums	Yes	No	No
c)Jaws	Yes	No	

82% of subjects (71 of 87) responded to this questionnaire. The following tables summarize this response.

1. How would you rate your overall experience with the whitening procedure?

Table 44. Question 1 responses, one-week follow-up questionnaire.

Treatment	Excellent	Very good	Fair	Poor
Peroxide-light	8 (32.0%)	15 (60.0%)	2 (8.0%)	0 (0.0%)
Peroxide	10 (43.5%)	10 (43.5%)	3 (13.0%)	0 (0.0%)
Light	8 (34.8%)	12 (52.2%)	3 (13.0%)	0 (0.0 %)

These differences were not statistically significant ($p=0.84$, Fisher's exact test).

2. Compared to your appearance immediately after the treatment, do you think that the whiteness of your teeth has decreased?

Table 45. Question 2 responses, one-week follow-up questionnaire.

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	2 (8.0%)	15 (60.0%)	7 (28.0%)	1 (4.0%)
Peroxide	9 (40.9%)	10 (45.5%)	2 (9.1%)	1 (4.6%)
Light	13 (56.5%)	8 (34.8%)	1 (4.4%)	1 (4.4%)

These differences were statistically significant ($p=0.005$, Fisher's exact test).

3. Compared to your appearance immediately after the treatment, do you think that the yellowness of your teeth has increased?

Table 46. Question 3 responses, one-week follow-up questionnaire.

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	14 (60.9%)	6 (26.1%)	3 (13.0%)	0 (0.0%)
Peroxide	10 (40.0%)	12 (48.0%)	3 (12.0%)	0 (0.0%)
Light	17 (73.9%)	5 (21.7%)	0 (0.0%)	1 (4.4%)

These differences were not statistically significant ($p=0.06$, Fisher's exact test).

4. Have your teeth been more sensitive after the procedure?

Table 47. Question 4 responses, one-week follow-up questionnaire.

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	10 (40.0%)	10 (40.0%)	3 (12.0%)	2 (8.0%)
Peroxide	11 (47.8%)	7 (30.4%)	3 (13.0%)	2 (8.7%)
Light	21 (91.3%)	2 (8.7%)	0 (0.0%)	0 (0.0%)

These differences were highly significant ($p=0.005$, Fisher's exact test).

5. Did you take Advil, Tylenol, aspirin, or any pain relief medications in order to relieve tooth sensitivity at any time after the procedure?

Table 48. Question 5 responses, one-week follow-up questionnaire.

Treatment	No	Yes
Peroxide-light	15 (60.0%)	10 (40.0%)
Peroxide	15 (65.2%)	8 (34.8%)
Light	23 (100.0%)	0 (0.0%)

These differences were highly significant ($p=0.0007$, Fisher's exact test).

6. Please tell us if you experienced sensitivity or discomfort in any other parts of your mouth, as listed below.

a) Lips

Table 49. Question 6a responses, one-week follow-up questionnaire.

Treatment	No	Yes
Peroxide-light	18 (72.0%)	7 (28.0%)
Peroxide	20 (90.9%)	2 (9.1%)
Light	23 (100.0%)	0 (0.0%)

These differences were significant ($p=0.008$, Fisher's exact test).

b) Gums

Table 50. Question 6b responses, one-week follow-up questionnaire.

Treatment	No	Yes
Peroxide-light	16 (66.7%)	8 (33.3%)
Peroxide	21 (91.3%)	2 (8.7%)
Light	22 (95.7%)	1 (4.4%)

These differences were significant ($p=0.02$, Fisher's exact test).

c) Jaws

Table 51. Question 6c responses, one-week follow-up questionnaire.

Treatment	No	Yes
Peroxide-light	17 (70.8%)	7 (29.2%)
Peroxide	20 (87.0%)	3 (13.0%)
Light	23 (100.0%)	0 (0.0%)

These differences were significant ($p=0.01$, Fisher's exact test).

3 and 6-month follow-up Questionnaire

- Compared to after treatment, has whiteness of your teeth decreased?
Not at all Slightly Moderately Greatly
- Compared to after treatment, has the yellowness of your teeth increased?
Not at all Slightly Moderately Greatly
- Did your teeth feel sensitive before the procedure?
Not at all Slightly Moderately Greatly
- Do your teeth feel sensitive now?
Not at all Slightly Moderately Greatly
- Did you have sensitive teeth at any time after the procedure?
Not at all Slightly Moderately Greatly
If yes, please explain _____
- Would you recommend this procedure to your friends?
Not at all May be Yes

Table 52. Question 1 responses, 3-month follow-up questionnaire.
Compared to after treatment, has whiteness of your teeth decreased?

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	8 (28.6%)	14 (50.0%)	4(14.3%)	2 (7.1%)
Peroxide	10 (35.7%)	12 (42.9%)	5 (17.9%)	1 (3.6%)
Light	13 (44.8%)	12 (41.4%)	3 (10.3%)	1 (3.4%)

Table 53. Question 1 responses, 6-month follow-up questionnaire.

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	3 (10.3%)	18 (62.1%)	6(20.7%)	2 (6.9%)
Peroxide	9 (32.1%)	13 (46.4%)	6(21.4%)	0 (0.0%)
Light	12 (41.4%)	9 (31.0%)	8 (27.6%)	0 (0.0%)

Table 54. Question 1 responses, 3-months pooled.

Treatment	None-slightly	Moderately-Greatly
Peroxide-light	22 (78.6%)	6 (21.4%)
Peroxide	22 (78.6%)	6 (21.4%)
Light	25 (86.2%)	4 (13.8%)
Average	81%	

Table 55. Question 1 responses, 6-months pooled.

Treatment	None-slightly	Moderately-Greatly
Peroxide-light	21 (72.4%)	8 (27.6%)
Peroxide	22 (78.6%)	6 (21.4%)
Light	21 (72.4%)	8 (27.6%)
Average	74%	

Although none of these differences are statistically significant between groups, the average percent of subjects reporting a none-slight reduction in whiteness goes from 81% at 3 months to 74% at 6 months. Although indicative of a trend to report a decrease in whiteness, this is not a statistically significant difference ($p=0.3$).

Table 56. Question 2 responses, 3-month follow-up questionnaire.
Compared to after treatment, has the yellowness of your teeth increased?

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	12 (42.9%)	12 (42.9%)	4(14.3%)	0 (0.0%)
Peroxide	13 (46.4%)	11 (39.3%)	4 (14.3%)	0 (0.0%)
Light	14 (48.3%)	13 (44.8%)	2 (6.9%)	0 (0.0%)

Table 57. Question 2 responses, 6-month follow-up questionnaire.

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	8 (27.6%)	17 (58.6%)	3(10.3%)	1 (3.4%)
Peroxide	12 (42.9%)	9 (32.1%)	6(21.4%)	1 (3.6%)
Light	10 (34.4%)	13 (44.8%)	6 (20.7%)	0 (0.0%)

Table 58. Question 2 responses, 3-months pooled.

Treatment	None-slightly	Moderately-Greatly
Peroxide-light	24 (85.7%)	4 (14.3%)
Peroxide	24 (85.7%)	4 (14.3%)
Light	27 (93.1%)	2 (6.9%)
Average	88%	

Table 59. Question 2 responses, 6-months pooled.

Treatment	None-slightly	Moderately-Greatly
Peroxide-light	25 (86.2%)	4 (13.8%)
Peroxide	21 (75.0%)	7 (25.0%)
Light	23 (79.3%)	6 (20.7%)
Average	80%	

Although none of these differences are statistically significant between groups, the average percent of subjects reporting a none-slight increase in yellowness goes from 88% at 3 months to 80% at 6 months. Although indicative of a trend to report increased tooth yellowing, this is not a statistically significant difference ($p=0.15$).

Table 60. Question 3 responses, 3-month follow-up questionnaire.

Did your teeth feel sensitive before the procedure?

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	26 (92.9%)	2 (7.1%)	0(0.0%)	0 (0.0%)
Peroxide	25 (86.2%)	3 (10.3%)	1 (3.4%)	0 (0.0%)
Light	25 (86.2%)	4 (13.8%)	0 (0.0%)	0 (0.0%)

Table 61. Question 3 responses, 6-month follow-up questionnaire.

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	27 (93.1%)	2 (6.9%)	0(0.0%)	0 (0.0%)
Peroxide	23 (82.1%)	4 (14.3%)	1(3.6%)	0 (0.0%)
Light	22 (75.9%)	7 (24.1%)	0(0.0%)	0 (0.0%)

These data indicate that on both the 3 and 6-month visit, 98.8% of the subjects reported that had either none or slight tooth sensitivity before the tooth whitening procedures.

Table 62. Question 4 responses, 3-month follow-up questionnaire.

Do your teeth feel sensitive now?

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	24(88.9%)	3 (11.1%)	0 (0.0%)	0 (0.0%)
Peroxide	23 (79.3%)	5 (17.2%)	1 (3.4%)	0 (0.0%)
Light	26 (89.7%)	3 (10.3%)	0 (0.0%)	0 (0.0%)

Table 63. Question 4 responses, 6-month follow-up questionnaire.

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	25 (86.2%)	4 (13.8%)	0 (0.0%)	0 (0.0%)
Peroxide	22 (78.6%)	5 (17.9%)	1(3.6%)	0 (0.0%)
Light	21 (72.4%)	7 (24.1%)	1 (3.4%)	0 (0.0%)

Table 64. Question 4 responses, 3-months pooled.

Treatment	None-slightly	Moderately-Greatly
Peroxide-light	27 (100.0%)	0 (0.0%)
Peroxide	28 (96.6%)	1 (3.4%)
Light	29 (100.0%)	0 (0.0%)
Average	99%	

Table 65. Question 4 responses, 6-months pooled.

Treatment	None-slightly	Moderately-Greatly
Peroxide-light	29 (100.0%)	0 (0.0%)
Peroxide	27 (96.4%)	1 (3.6%)
Light	28 (96.6%)	1 (3.4%)
Average	98%	

Although tooth sensitivity was reported by several subjects immediately following treatment by the 3-month visit, virtually none of the subjects reported residual tooth sensitivity.

Table 66. Question 5 responses, 3-month follow-up questionnaire.

Did you have sensitive teeth at any time after the procedure?

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	10(35.7%)	9 (32.1%)	6 (21.4%)	3(10.7%)
Peroxide	16(55.2%)	11(37.9%)	1 (3.4%)	1 (3.4%)
Light	26(89.6%)	3(10.3%)	0 (0.0%)	0 (0.0%)

p < 0.0001

Table 67. Question 5 responses, 6-month follow-up questionnaire.

Treatment	Not at all	Slightly	Moderately	Greatly
Peroxide-light	10(34.5%)	11(37.9%)	5(17.2%)	3(10.3%)
Peroxide	13(46.4%)	12(42.9%)	2(7.1%)	1(3.6%)
Light	20(69.0%)	8 (27.6%)	1 (3.4%)	0 (0.0%)

P=0.08

Table 68. Question 5 responses, 3-months pooled.

Treatment	None-slightly	Moderately-Greatly
Peroxide-light	19 (76.9%)	9 (32.1%)
Peroxide	27 (93.1%)	2 (6.9%)
Light	29 (100.0%)	0 (0.0%)

p < 0.0001

Table 69. Question 5 responses, 6-months pooled.

Treatment	None-slightly	Moderately-Greatly
Peroxide-light	21 (72.4%)	8 (27.6%)
Peroxide	25 (89.3%)	3 (10.7%)
Light	28 (96.6%)	1 (3.4%)

P=0.02

These data indicate that tooth sensitivity was recognized most often in the peroxide+ light treated group and least often in the light control group. These differences were statistically significant, indicating that 8-9% of the peroxide + light treated group and 2-3% of the peroxide control group recognized increased tooth sensitivity at some time after the treatment procedure.

Table 70. Question 6 responses, 3-month follow-up questionnaire.

Would you recommend this procedure to your friends?

Treatment	Not at all	Maybe	Yes
Peroxide-light	1 (3.6%)	10 (35.7%)	17(60.7%)
Peroxide	2 (6.9%)	11 (37.9%)	16 (55.2%)
Light	0 (0.0%)	16 (57.1%)	12 (42.9%)

P = 0.3

Table 71. Question 6 responses, 6-month follow-up questionnaire.

Treatment	Not at all	Maybe	Yes
Peroxide-light	2 (6.9%)	10 (34.4%)	17(58.6%)
Peroxide	5 (17.9%)	8 (28.6%)	15(53.6%)
Light	2 (7.4%)	13 (48.1%)	12 (44.4%)

P = 0.4

Table 72. Question 6 responses, 3-months pooled.

Treatment	Not at all	Yes - Maybe
Peroxide-light	1 (3.6%)	27 (96.4%)
Peroxide	2 (6.9%)	27 (93.1%)
Light	0 (0.0%)	28 (100.0%)

P = 0.4

Table 73. Question 6 responses, 6-months pooled.

Treatment	Not at all	Yes - Maybe
Peroxide-light	2 (6.9%)	27 (93.1%)
Peroxide	5 (17.9%)	23 (82.1%)
Light	2 (7.4%)	25 (92.6%)

P = 0.3

Although none of these differences are statistically significant between groups, the peroxide-light treatment group consistently received the highest approval rating.

The reason for not recommending these treatments was not clear. It did not appear to be tooth sensitivity. At the 6-month visit, all subjects responding negatively and treated with either peroxide-light (n = 2) or light control (n = 2) reported not having sensitive teeth at any time after the treatment. Of the subjects receiving peroxide alone and responding negatively (n = 5), two reported not having sensitive teeth, two reported having slightly sensitive teeth and only one reported having moderately sensitive teeth (see question 5 above for comparison).

Failure to whiten teeth does not appear to explain this negative response either. The following table summarizes these comparisons based on tooth shade

Table 74. Shade change of subjects who did not recommend the procedure to their friends.

Treatment	Average pre - post-therapy shade change of group (mean \pm SD)	Average pre - post-therapy shade change of negative responders
Peroxide-light	8.34 \pm 2.07 (29)	6.75 (2)
Peroxide	5.89 \pm 1.28 (29)	5.45 (5)
Light	4.93 \pm 2.48 (29)	5.00 (2)

Food Survey

At the 3-month visit, a survey of the foods regularly consumed by participants in the study was administered. Responses were obtained from 77% of the subjects (67/87). Analysis of the impact of these data on tooth color change was accomplished by considering ANCOVA of the 6-month change in shade (the 6-month shade – the post-treatment shade) as the outcome variable, food consumption (either yes or no) as the categorization variable and pre-treatment shade as the covariate. By this analysis, it became clear that one of the strongest relationships was the effect of initial shade on the rate that teeth become darker after a tooth lightening procedure. This is illustrated in the following figure.

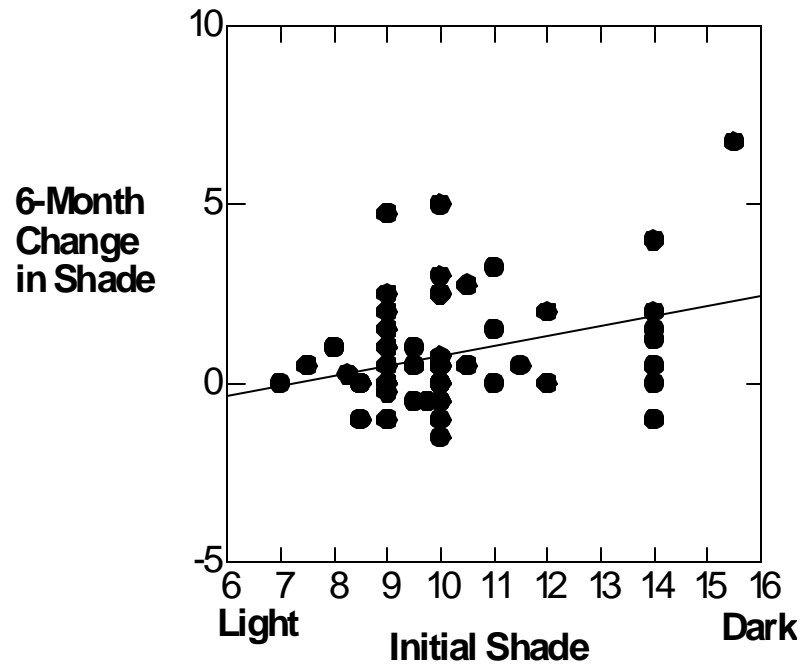


Figure 24 Change in shade from the immediate post treatment period to 6 months for teeth of differing pre-treatment shade. The slope of the 6-month shade change was 0.276 shade units per initial shade value. All treatments were considered together for this analysis. The correlation coefficient for this regression analysis was 0.329 and the ANOVA p-value was 0.007.

These data indicate that the darkest teeth tended to lose their whitening effect more rapidly than the teeth that were initially lighter (the “relapse” effect). Hence, for example a tooth at a shade value of 8 (D4) would increase to $8 + 0.276 \cdot 8 = 8 + 2.2 = 10.2$ (approximately D3) over 6 months. A tooth at initial shade 12 (A3.5) would increase to $12 + 0.276 \cdot 12 = 12 + 3.3 = 15.3$ (approximately A4) over 6 months.

Testing all subjects in the study for this shade relapse effect, the average change from post-treatment to 6 months was -1.16 , -0.42 , -0.72 shade units for peroxide + light, peroxide alone, and light alone groups respectively. These differences, however, were not statistically different by ANCOVA.

Effects of food consumption on tooth darkening following treatment were much smaller as indicated in the following table.

Table 75. Mean shade change values from post-therapy to 6-months (\pm S.D) of high and low-consumption ends in each food or drink category. Values are ordered by mean difference. The correlation coefficient is provided as an indication of the extent of association.

Consumption of:	High consumption shade change	Low-consumption shade change	Mean Difference	Correlation Coefficient (Spearman)
Red wine	1.75 \pm 2.86 (5)	0.53 \pm 1.28 (40)	1.22	0.163
Coffee (any)	1.75 \pm 2.79 (6)	0.61 \pm 1.04 (14)	1.14	0.045
Beets	1.64 \pm 1.89 (11)	0.76 \pm 1.52 (42)	0.88	0.045
Tea	1.35 \pm 1.93 (5)	0.69 \pm 1.53 (47)	0.66	0.069
Yellow sauces	0.94 \pm 2.27 (13)	0.95 \pm 1.31 (24)	-0.01	-0.132
Citrus fruits	0.76 \pm 1.62 (25)	1.03 \pm 0.99 (8)	-0.27	-0.097
Other juice	1.22 \pm 1.91 (19)	1.59 \pm 1.65 (8)	-0.37	-0.002
Red sauces	0.60 \pm 1.38 (40)	1.30 \pm 1.49 (10)	-0.7	-0.192
Cigarettes	0.30 \pm 0.84 (5)	0.88 \pm 1.58 (60)	-0.58	-0.127
Berries	0.17 \pm 0.29 (3)	1.09 \pm 1.70 (20)	-0.92	-0.045

These data suggest that consumption of red wine, coffee, beets and tea may hasten the darkening of teeth following tooth whitening procedures. Other food groups tested do not appear to affect the process. As indicated by the correlation coefficients, most correlations were less than 0.1, indicating an extremely small effect. None were so strong as to be convincingly considered statistically significant.

Discussion

Tooth whitening

This study demonstrated that both peroxide and light had significant bleaching capacity but the combination of the two have produced a significantly greater bleaching effect. Analysis by shade guide and chromameter revealed an average change of 8.34 shade guide increments, 3.98 L* whiteness units and 4.07 b* yellowness units occurred using the peroxide + light treatment. The following figure summarizes these data in graphic form.

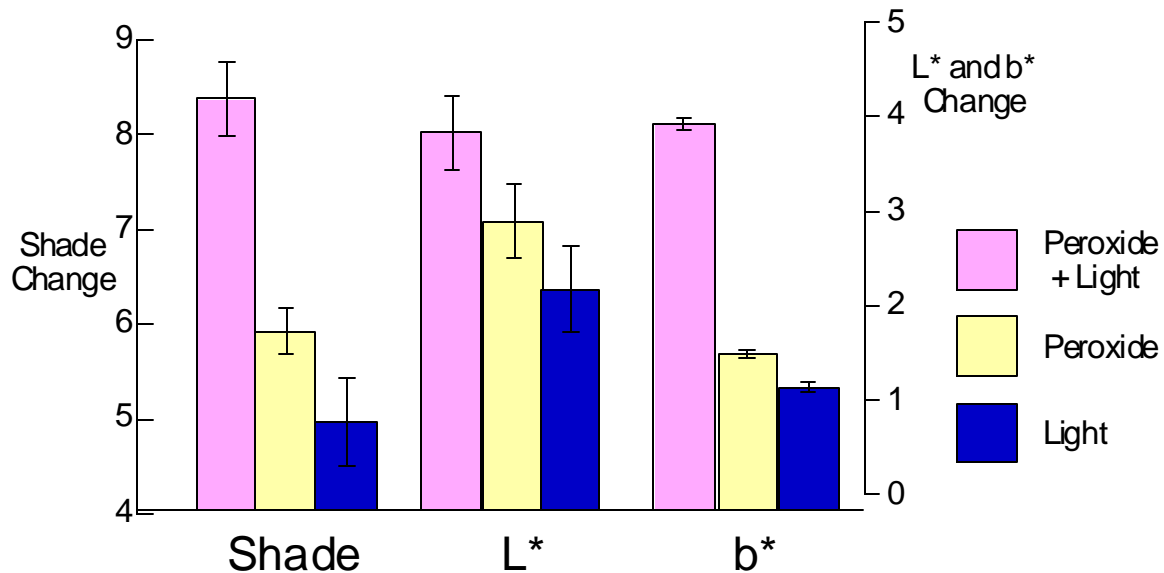


Figure 25. Comparison of changes in shade, L* (lightness) and b* (decreased yellowness). Mean changes for peroxide + light treatment were significantly greater than either peroxide alone or light alone.

One of the surprising findings of this study was that light by itself appears to have a substantial whitening effect. This was seen in shade guide evaluations (Table 9), L* change (Table 14) and the b* change (Table 20). When compared with pre-treatment all of these measures of bleaching effect had changed significantly with treatment. In addition, the post-therapy questionnaire reported that 53.6% of subjects treated by light recognized a moderate to great increase in whiteness (Table 35) and 51.7% of subjects recognized a moderate to great decrease in yellowness following treatment by light alone.

These patterns were maintained with only slight diminution over the 6-month observation period (figure 12). Statistical analysis revealed that the peroxide + light treated group maintained a statistically significant difference with both controls throughout the observation period (tables 10, 11, 12). Extrapolation of shade data suggested that 2.3% of the treatment effect is lost each month. At this rate, the treatment should fall to its approximate half value in 1.8 years and some evidence of effect should be apparent for 3.6 years (figure 13).

The effect on the chromameter whiteness parameter (L^*) responded similarly to the shade (figure 15). In this case, however, significant difference between the peroxide + light treatment group persisted only with respect to the light control group. By the 3-month observation, the light control group was not significantly different than pre-treatment. The difference between peroxide + light and peroxide alone was statistically significant only at the pre- to post-treatment measurement. (Table 15).

The effect of the peroxide + light treatment on decreasing yellowness (b^*) was significantly greater than all treatment groups (figure 19, table 21). It appears that reduction in tooth yellowness is principal effect of all tooth whitening procedures tested.

Gingival and Plaque index

Both the gingival and plaque indices were low in this subject group indicating a high degree of oral health care maintenance (table 25). Despite the initially low average gingival index value (0.64), the peroxide + light treatment significantly (table 26) decreased the gingival index further (0.28). This effect was not statistically significant in the other treatment groups. It is interesting to speculate that the treatment might alter the gingival microbiota. In contrast, the plaque index did not change. It was low to start and it staid low (figure 23).

Intraoral examination

Of the intraoral structures examined, only two categories had contained noteworthy responses; those concerned with gingival health and tooth sensitivity. The general clinical impression associated with these observations was that that adverse reactions seldom occurred and were relatively minor.

Post-therapy questionnaire responses

Subject perception that the peroxide + light treatment produced superior whitening response agreed with the shade guide and chromameter responses. From table 33, the following figure has illustrated the percentage of subjects who rated their increase in whiteness in the moderately to greatly categories.

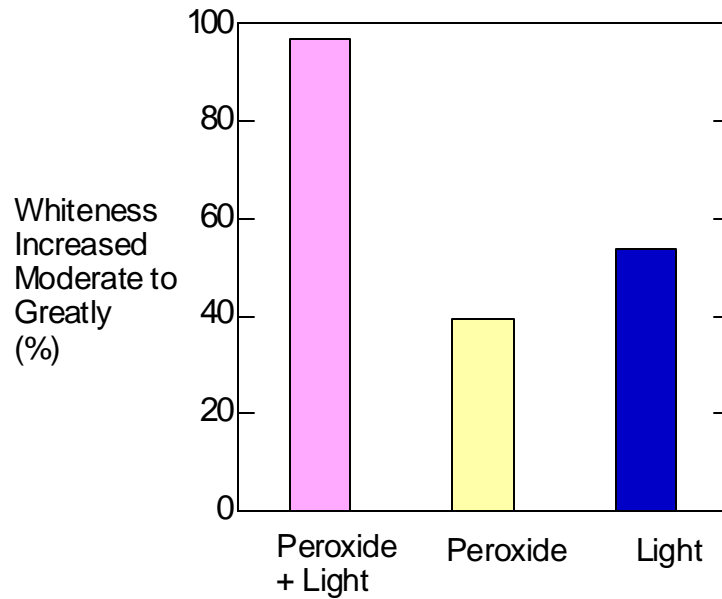


Figure 26. Response to the question “How much did the product increase the whiteness of your teeth?” These differences were found statistically significant ($p=0.001$).

The differences in subject responses to the question concerning decreases in yellowness were similar but not quite as dramatic as their perception of whiteness change. These differences were summarized in the following figure (Figure 18).

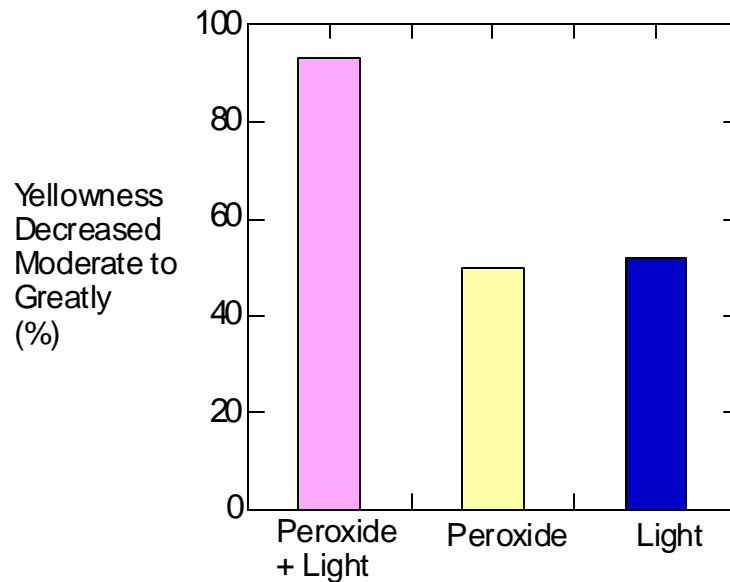


Figure 27. Response to the question “Did the test product reduce the yellowness of your teeth?” These differences were found statistically significant ($p=0.001$).

No significant differences between groups were seen in the subject responses to the question relating to feeling any discomfort during the procedure. In general, 3 to 5 subjects in each group responded

that moderate to great discomfort was felt during the procedure. These responses were summarized graphically in Figure 19.

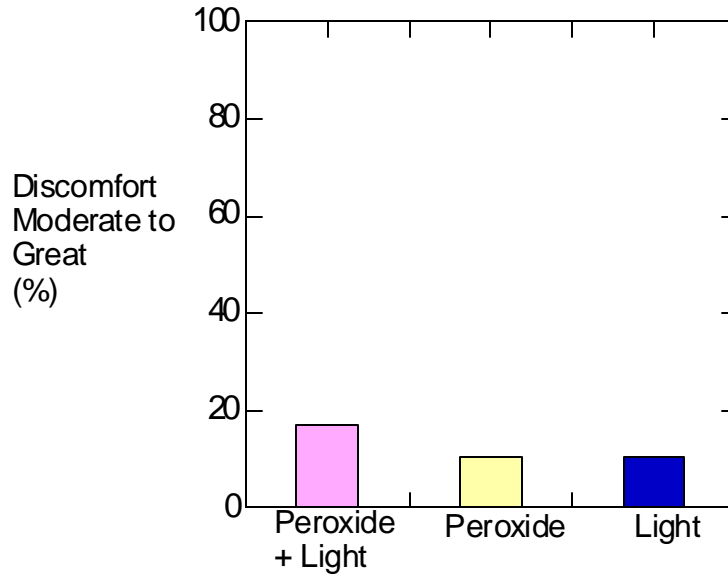


Figure 28. Response to the question “Did you feel any discomfort during the procedure?” These differences were not statistically significant ($p=0.66$).

A question related to subject discomfort was #4 “Did your teeth feel sensitive before the procedure.” and #5 “Did your teeth feel sensitive before the procedure.” Before the procedure, there were no positive responses to tooth sensitivity. After the procedure, there appeared to be a trend toward higher incidence following treatment with peroxide + light. As indicated in the following figure (Figure 20), this trend was not statistically significant.

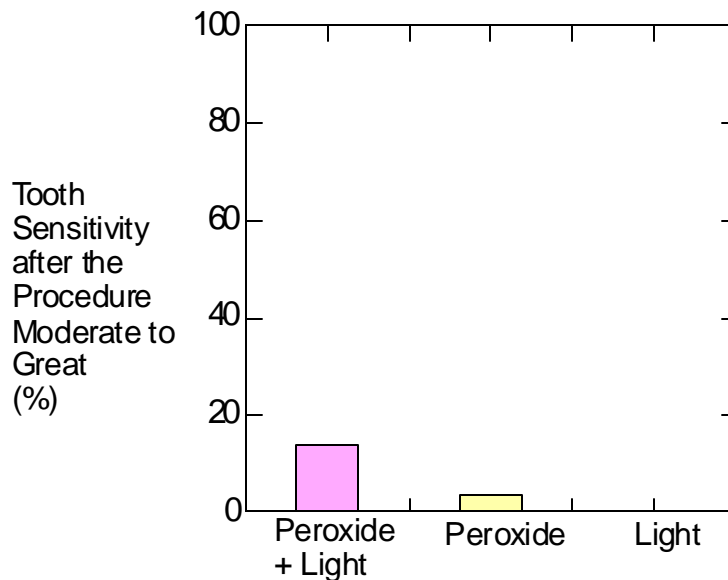


Figure 29. Response to the question “Did your teeth feel sensitive after the procedure?” These differences were not statistically significant ($p=0.12$).

When asked whether subjects would recommend their treatment to a friend, approximately 95% responded “Yes” or “Maybe”. Only 4 subjects (in the peroxide alone group) indicated that they would not recommend the procedure to a friend. Of those who responded definitely “Yes”, the light + peroxide treatment received the largest percentage. The following figure (Figure 21) illustrates this difference.

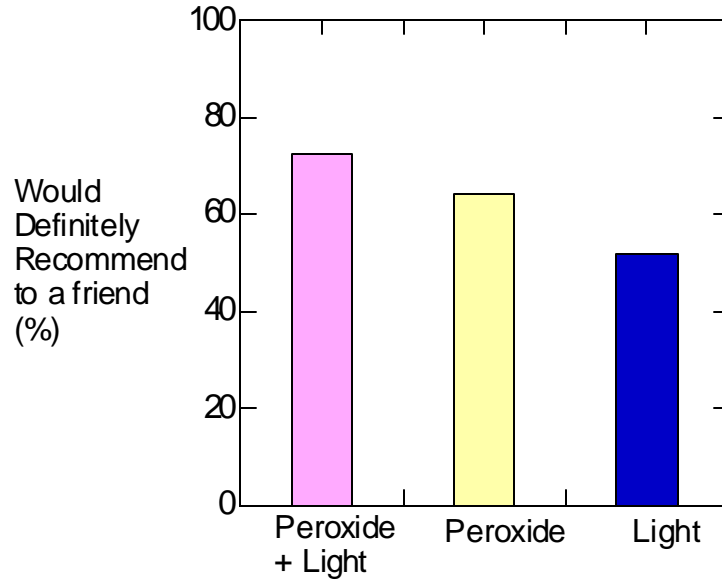


Figure 30. Response to the question “Would you recommend this procedure to your friends?” These differences were statistically significant ($p=0.01$).

Oral examination and post-therapy questionnaire responses

The gingival examination revealed that 10 subjects exhibited post therapy gingival redness (Table 25). Of these, 6 were treated by peroxide + light (the BriteSmile treatment), 2 were treated by peroxide alone and 2 were treated by light alone (Table 27). To investigate the severity of this observation from the subject’s perspective, responses to the following post-therapy questionnaire for these subjects were collected (Table 76).

3. Did you feel any discomfort during the procedure?
Not at all Slightly Moderately Greatly
5. Did your teeth feel sensitive after the procedure?
Not at all Slightly Moderately Greatly
6. Would you recommend this procedure to your friends?
Not at all May be Yes

From the subject’s point of view, detection of gingival redness by the examining dentist appeared to have little effect on their attitude toward their treatment. In the following table, questionnaire responses relevant to accessing the magnitude of discomfort perceived by the 10 subjects is tabulated. Most listed discomfort and sensitivity as none to slight (one was moderately sensitive) and almost all seemed willing to recommend the procedure to friends.

Table 76: Summary of post-therapy questionnaire responses of the 10 subjects identified as having gingival redness (Table 27 and 28). Responses to questions on discomfort, tooth sensitivity and willingness to recommend the procedure to friends are tabulated. Values in parentheses are numbers of those treated by peroxide + light.

	3) Discomfort?	5) Sensitive?	6) Recommend?
Not at all	2	7(4)	9(6)-yes
Slightly	8(6)	2(1)	1-maybe
Moderately	0	1(1)	0-no
Greatly	0	0	
Total	10(6)	10(6)	10(6)

The tooth examination also revealed that 10 subjects exhibited some degree of post therapy tooth sensitivity (Table 27). Of these 8 were treated by peroxide + light, 1 was treated by peroxide alone and 1 was treated by light alone (Table 10). In a manner similar to the analysis of the preceding section, the responses to the post-therapy questionnaire for these subjects were collected for analysis. As indicated in Table 77, these subjects rated their discomfort and tooth sensitivity from not at all to moderate with one individual expressing their tooth sensitivity in the "Greatly" category. Interestingly, when asked the question "Would you recommend the procedure to a friend, 5 said yes, 3 said maybe and none said no. One may conclude from this observation that the subjects benefit analysis generally outweighed their concerns of tooth sensitivity.

Table 77: Summary of immediate postoperative questionnaire responses of the 10 subjects identified as having tooth sensitivity (Tables 25 and 30). Responses to questions on discomfort, tooth sensitivity and willingness to recommend the peroxide + light tooth whitening procedure to friends were tabulated. Values in parentheses were numbers of those treated by peroxide + light.

	3) Discomfort?	5) Sensitive?	6) Recommend?
Not at all	1(0)	3(1)	6(5)-yes
Slightly	7(6)	4(4)	4(3)-maybe
Moderately	2(2)	2(2)	0(0)-no
Greatly	0	1(1)	
Total	10(8)	10(8)	10(8)

One-week follow-up questionnaire responses

Eighty-eight percent of subjects rated the overall experience of in-office tooth whitening as excellent to very good irrespective of their treatment group. Only 8 subjects (9.3%) responded that the experience was “Fair” and none responded “poor”. Differences between groups were not statistically significant.

When asked whether there had been a decrease in tooth whiteness one week after treatment there was a significant trend for subjects treated by peroxide + light to indicate that a reduction had occurred. This is summarized in the following figure (Figure 22).

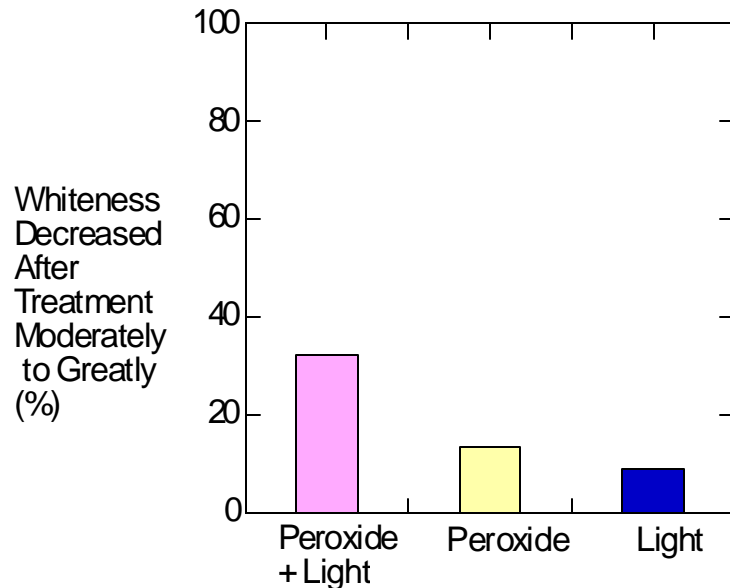


Figure 31. Response to the question “Compared to your appearance immediately after the treatment, do you think that the whiteness of your teeth has decreased?” These differences were statistically significant ($p=0.005$ by Fisher’s exact test).

In these responses, subjects seemed to feel that the most effective treatment (peroxide + light) may have had the most noticeable relapse. This observation was not borne out by analysis of the shade data. (figure 24). By this analysis it was found that relapse depended strongly on the initial shade with darker pre-treatment shades darkening more rapidly after therapy. This effect over the 6-month study

period was 0.276 shade units per initial shade value. No statistically significant effects on this relapse rate were observed between treatments. Irrespective of this so-called “relapse” rate, the average subject treated by the peroxide + light treatment maintained 86.1% of their treatment effect at the 6-month visit.

When asked the parallel question “ Compared to your appearance immediately after the treatment, do you think that the yellowness of your teeth has increased?” 93 % of the subjects responded not at all to slightly irrespective of their treatment group. These differences were not statistically significant ($p=0.06$, Fisher’s exact test).

When asked the question “Have your teeth been more sensitive after the procedure.” approximately 20% of subjects treated either by peroxide + light or peroxide alone responded “Moderately” to “Greatly”. In contrast, none of the subjects treated by light alone reported moderate to great increases in tooth sensitivity. The results were summarized in the following figure.

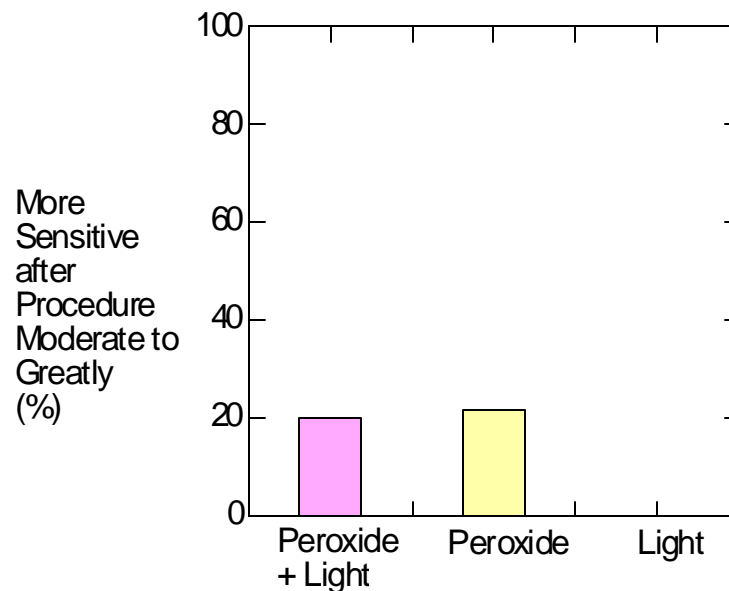


Figure 32. Response to the question “Have your teeth been more sensitive after the procedure?” These differences were statistically significant ($p=0.005$ by Fisher’s exact test).

These results (Tables 47 and 48 and figures 32 and 33) suggested that tooth sensitivity following tooth-whitening procedures was primarily related to the peroxide.

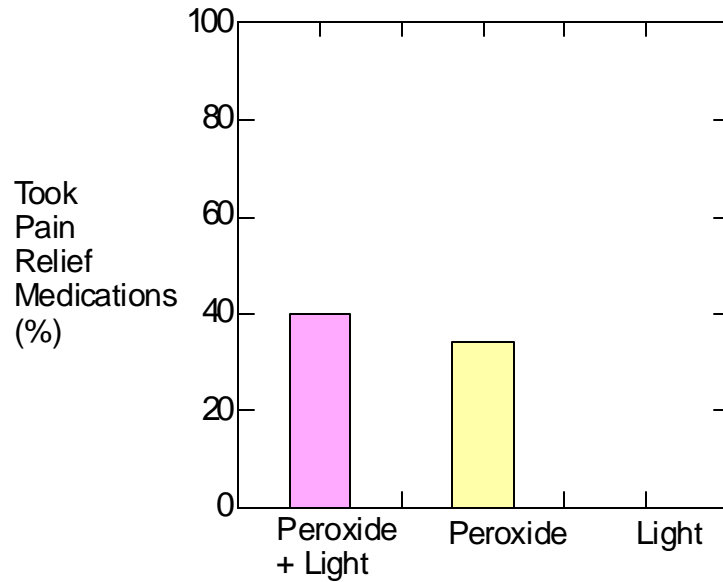


Figure 33. Response to the question “Did you take Advil, Tylenol, aspirin, or any pain relief medications in order to relieve tooth sensitivity at any time after the procedure?” These differences were statistically significant ($p=0.0007$ by Fisher’s exact test).

In response to the question “Please tell us if you experienced sensitivity or discomfort in any other parts of your mouth (lips, gums and jaws) the frequency of “yes” responses was greatest with peroxide + light treatment, less with peroxide alone and least with light alone. All of these differences were statistically significant (Tables 40, 41 and 42). These results were summarized in the following figure.

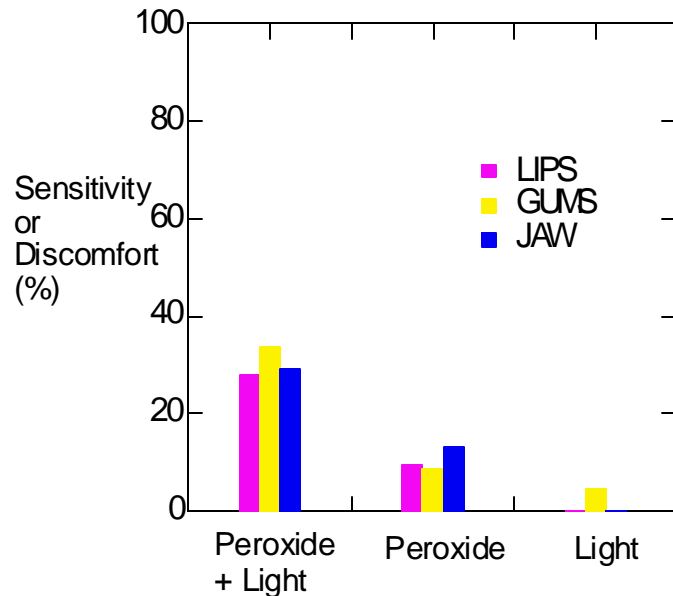


Figure 34. Response to the question “Please tell us if you experienced sensitivity or discomfort in any other parts of your mouth?” Statistically significant differences existed in all questionnaire responses (Lips, $p=0.008$, gums, $p=0.02$, jaws, $p=0.01$ by Fisher’s exact test).

3- and 6-Month follow-up questionnaire responses

When asked “, has whiteness of your teeth decreased” , 78.6% (3-month) and 72.4% (6-month) of subjects treated by peroxide + light indicated none to slight (tables 54 and 55) this was slightly better than the response obtained immediately post-therapy (table 45) that indicated that 68% felt that a none to slight change had occurred. In all, it suggests that the subject evaluation of the treatment effect has remained relatively stable over the 6-month period of evaluation.

When asked “, has yellowness of your teeth increased” , 85.7% (3-month) and 86.2% (6-month) of subjects treated by peroxide + light indicated none to slight (tables 58 and 59) this was essentially the same as the response obtained immediately post-therapy (table 46) that indicated that 87% felt that a none to slight change had occurred. This too suggests that the subject evaluation of the treatment effect has remained relatively stable over the 6-month period of evaluation.

When asked “Do your teeth feel sensitive now?”, all subjects treated by peroxide+ light responded non to slight (tables 64 and 65). These data indicate that tooth sensitivity by this treatment procedure was transient and by 3 months, none of the subjects were aware of it to any major extent. It also suggests that one of the most important concerns, post-therapy pulpitis does not appear to be a problem with this treatment. Still, when asked “Did you have sensitive teeth at any time after the procedure?”, 8 to 9 % of the subjects reported moderately to greatly, indication that in the early post-therapy period a small percentage of subjects did feel the discomfort of sensitive teeth.

When asked “Would you recommend this procedure to your friends?”, 96.4% (3-month) and 93.1 % (6-month) of the subjects treated with peroxide + light responded “yes to maybe” (Tables 72 and 73). This was slightly less than the 100% response obtained in the post-treatment questionnaire (table 43). When the 2 subjects were identified that would not recommend to a friend, they were found to have received an excellent tooth-whitening response (table 74) and did not experience tooth sensitivity. The reasons for their not recommending to their friends is not clear at this time.

Food Survey

Analysis of the effect of smoking and consuming colored foods and beverages was evaluated by testing its effect on the shade change from post-therapy to 6-months. The most important variable controlling the “relapse” rate was the pre-treatment shade. All other consumption patterns had little effect. Of those tested, red wine appeared most important. Over the period of the study, however, effect had only decreased by approximately 15%. To observe effect of these type of habits will likely require longer observation periods.

Conclusions

Tooth whitening using the peroxide + light treatment (BriteSmile therapy) was found effective and safe. Adverse reactions were transient and did not detract from positive subject responses to the therapy. This study demonstrated that the application of light by itself had a significant bleaching effect. As expected, application of peroxide by itself also had a significant bleaching effect. The combination of the two, however, resulted in significant increment in tooth whitening not achieved by either peroxide or light alone. This form of therapy, the BriteSmile treatment, produced an average of 8.3 shade guide increments lightening after a one-hour treatment. All subjects received a measurable lightening effect between 4 and 13 shade guide increments.

The most common side effect of therapy was tooth sensitivity. The pattern of subject responses indicated that this side effect is associated with peroxide and unrelated to the use of light. The magnitude of this side effect occasionally prompted mild analgesic therapy but was generally tolerated and did not appear to detract from the positive response subjects had toward tooth whitening. Questionnaire responses at the 3 and 6 month visit indicated that tooth sensitivity had largely disappeared. The second most common side effect was redness and irritation of the soft tissues. This also disappeared rapidly and was hardly noticed by the subjects themselves.

As designed, this study clearly demonstrated the synergistic effects of light and peroxide in tooth bleaching. The attention to detail in protecting soft tissues from chemical and light irritation is clearly related to the low incidence and intensity of side effects seen in this study. The in-office of the procedure deserves special note. It was generally felt that much of the safety of the procedure was the result of the professional control over the potentially irritating products being used. It was also found to be extremely dependable by virtue that all subjects treated received at least 4 shade guide increments of tooth lightening. The effectiveness of the procedure was indicated by average changes greater than 8 shade guide increments and some as large as 13 shade guide increments. The lasting benefit of the treatment was indicated by maintaining 86.1% of the shade reduction effect at 6-months.

References

- Anonymous (1994) Guidelines for the acceptance of peroxide-containing oral hygiene products. American Dental Association Council on Dental Therapeutics. *Journal of the American Dental Association* **125**, 1140-1142.
- Anonymous (1998) *ADA Guide to Dental Therapeutics*. Chicago Ill.: ADA Publishing Co.
- Berger-Schunn,A. (1994) *Practical color measurement*. New York, N.Y.: John Wiley & sons.
- Loe, H. and J. Silness. (1963) Periodontal disease in pregnancy. I. Prevalence and severity. *Acta Odont. Scand* **21**:533-551.
- Kowitz,G.M., Nathoo,S.A., Rustogi,K.N., Chmielewski,M.B., Liang,L.J. & Wong,R. (1994a) Clinical comparison of Colgate Platinum Toothwhitening System and Rembrandt Gel Plus. *Compendium Suppl 17*, S646-S651
- Kowitz,G.M., Nathoo,S.A. & Wong,R. (1994b) Comparative clinical evaluation of two professional tooth-whitening products. *Compendium Suppl 17*, S635-S639
- Matis,B.A., Cochran,M.A., Eckert,G. & Carlson,T.J. (1998) The efficacy and safety of a 10% carbamide peroxide bleaching gel. *Quintessence International* **29**, 555-563.
- Meyers,M.I., Dickinson,G.L., Curtis,J.W., Jr. & Russell,C.M. (1995) Evaluating color change following vital tooth bleaching. *J Esthet Dent* **7**, 256-262.
- Nathoo,S.A., Chmielewski,M.B. & Rustogi,K.N. (1994) Clinical evaluation of Colgate Platinum Professional Toothwhitening System and Rembrandt Lighten Bleaching Gel. *Compendium Suppl 17*, S640-S645
- Ouellet,D., Los,S., Case,H. & Healy,R. (1992) Double-blind whitening Night-Guard study using ten percent carbamide peroxide. *Journal of Esthetic Dentistry* **4**, 79-83.
- Rosenstiel,S.F., Gegauff,A.G. & Johnston,W.M. (1996) Randomized clinical trial of the efficacy and safety of a home bleaching procedure. *Quintessence International* **27**, 413-424.
- Rustogi,K.N. & Curtis,J. (1994) Development of a quantitative measurement to assess the whitening effects of two different oxygenating agents on teeth in vivo. *Compendium Suppl 17*, S631-S634
- Silness J. and Loe, H. (1964) Periodontal disease in pregnancy II. Correlation between oral hygiene and periodontal condition. *Acta Odont. Scand* **22**: 121-135.