Desensitizing Agent Efficacy during Whitening in an At-Risk Population

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ABSTRACT

Background: Nightguard vital bleaching (NGVB) has gained acceptance among dentists and patients as a simple and effective procedure to lighten discolored teeth. Although the efficacy and predictability of NGVB have been well established, it has been documented that patients undergoing the procedure may experience side effects such as tooth sensitivity (TS) and gingival irritation (GI). A previous NGVB study suggested that selected participants might benefit from a regimen of a desensitizing agent (DSA) to decrease or prevent TS during whitening.

Purpose: The purpose of this study was to determine whether the daily use of an active DSA (UltraEZ™, Ultradent Products Inc., South Jordan, UT, USA) during NGVB would decrease TS in a population at risk for TS when compared with a placebo.

Materials and Methods: Forty subjects participated in this single-blind randomized clinical trial. All participants had indicated that they had preexisting TS or other risk factors for TS during NGVB. To evaluate TS caused by the tray alone, participants wore custom-fitted maxillary whitening trays containing no DSA or whitening solution during week 1. Next, participants were randomly assigned to apply either the active DSA or placebo daily for 14 days in the trays for 30 minutes prior to whitening. The placebo was the same formulation as UltraEZ but without the desensitizing agents (3% potassium nitrate and 0.11% by weight fluoride ion). The bleaching solution was a 10% carbamide peroxide whitening solution (Opalescence™, Ultradent Inc.). Post treatment, participants were followed up for 1 week, during which time they used neither trays nor solutions. Throughout the study, participants completed a daily diary to record their perceptions of TS and the time spent wearing the tray with the whitening solution.

Results: Forty-one percent of the active group had at least 1 day of TS during treatment compared with 78% of the placebo group. The difference was statistically significant ($p = .027$) using the two-tailed Fisher exact test.

CLINICAL SIGNIFICANCE

This study suggests that the use of an active 3% potassium nitrate and 0.11% fluoride desensitizing agent for 30 minutes prior to whitening may decrease tooth sensitivity when compared with a placebo in a population at risk for tooth sensitivity.

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Since its introduction to dentistry by Haywood and Heymann in 1989, nightguard vital bleaching (NGVB) has gained acceptance among dentists and patients as a simple and effective procedure to lighten extrinsically stained or discolored teeth.[1] Although the efficacy and predictability of NGVB have been well established, it has been documented that patients undergoing the procedure may experience transient adverse side effects,[2–13] the most prevalent being tooth sensitivity (TS) and gingival irritation (GI).[5,7,14–18] These side effects can be a major deterrent to successful completion of treatment and are thus a concern for dentists, patients, and manufacturers of whitening solutions.

Previous studies have shown that if TS develops during NGVB, it can be treated by decreasing the amount of solution in the whitening tray, decreasing the number of hours worn per treatment application, or interrupting treatment for a few days.[7,19–21] A more active approach to treating TS associated with NGVB is the application of desensitizing agents (DSAs).[14]

Two commonly used DSAs to treat TS during NGVB are neutral fluoride and 3 to 5% potassium nitrate. Fluoride has been used to occlude tubules and has been shown to reduce TS. Potassium nitrate has been shown to have desensitizing properties and works primarily by compromising the nerve's ability to transmit pain. Haywood and colleagues showed that participants experiencing TS during NGVB could benefit from a 5% potassium nitrate–fluoride gel when applied as needed during whitening.[14] This reduction in TS during whitening allowed most participants to continue whitening through to the completion of treatment. Matis and colleagues also showed the benefit of a desensitizing gel after participants experienced TS during whitening.[22] However, these modalities addressed TS only after it had occurred.

The literature is unclear on the generic or preventive use of DSAs added to the actual whitening solution. Nonetheless, manufacturers have added DSAs to their whitening solutions so that all patients undergoing NGVB can reap the benefits of the desensitizing properties. Jorgensen and Carroll reported in their study that 68% of participants using a 15% carbamide peroxide whitening solution with 0.11% fluoride ion experienced TS.[15] This is comparable to other reported studies using a lower carbamide peroxide concentration without any type of DSA or the same carbamide peroxide concentration without a DSA by another manufacturer.[5,17,21–23] Three other studies have evaluated the effect of a whitening solution containing a DSA against a whitening solution without one.[24–26] The results are similar in that no statistically significant differences existed for the solutions. However, one benefit of the DSA was that those participants using the whitening solution with a DSA returned to their pretreatment sensitivity levels quicker or to a lower level of sensitivity than did those using a whitening solution without a DSA.

Pohjola and colleagues reported x on two 10% carbamide peroxide whitening products that contained potassium nitrate and were advertised as zero-sensitivity products and a third 10% carbamide peroxide product that did not contain potassium nitrate.[18] Unlike the other studies mentioned, Pohjola and colleagues reported that participants using the 10% carbamide peroxide products with potassium nitrate did not experience any thermal TS, whereas those using the product without the potassium nitrate did experience TS. They also concluded that none of the products could claim "zero sensitivity" since participants did experience other forms of sensitivity. In these studies participants were treated the same with respect to the risk for developing TS during NGVB, although experience shows this is not the case. Additionally, the literature tells us that TS develops in some patients who are using a placebo alone and in others who are wearing a treatment tray with-

out any treatment solution.[21,27] Therefore, TS and the development of other side effects during whitening are multifactorial phenomena and are not exclusively dependent upon the use of whitening solution.

Another approach to prevent or decrease TS when whitening is to treat all patients with a DSA prior to active whitening. In a pilot study conducted by Smith and colleagues, it was concluded that the routine use of a 30-minute DSA (UltraEZ™, Ultradent Products Inc., South Jordan, UT, USA) prior to whitening in a general population was not statistically significant and was therefore not effective in preventing or decreasing TS.[28] However, the study did suggest that selected participants might benefit from a regimen of DSA to decrease or prevent TS during whitening. These participants were the ones answering yes to questions regarding preexisting sensitivity, consumption of citrus drinks or sodas on a daily basis, or the use of toothpaste, fluoride, or a dental restoration to treat sensitive teeth. Therefore, the objective of the present study was to determine whether the daily use of an active DSA (UltraEZ) prior to whitening would prevent or decrease TS when compared with a placebo in an at-risk population.

MATERIALS AND METHODS

Forty subjects participated in this single-blind randomized NGVB clinical trial. All participants had responded to a questionnaire indicating that they may be at risk for developing TS while undergoing NGVB treatment (Table 1). Participants completed an approved informed consent form and medical history form prior to undergoing an oral examination. All participants were at least 18 years of age with no significant medical problems. Additionally, no participant had active caries, defective restorations, or periodontal disease. An alginate impression of the maxillary arch was made using an irreversible hydrocolloid (Jeltrate Plus®, Dentsply/Caulk, Milford, DE, USA) from which a stone cast was generated; a 0.035 inch soft tray material (Sof-Tray®, Ultradent Products Inc.) was used to fabricate the treatment tray. The treatment tray was scalloped terminating at the junction of the tooth and gingiva and had facial reservoirs. To evaluate TS caused by the tray alone, participants wore the custom-fitted maxillary treatment tray containing no DSA or whitening solution for 1 week. Participants were assigned at random to apply either the active DSA or placebo daily for 14 days in the trays for 30 minutes prior to

TABLE 1. PARTICIPANTS RESPONDING POSITIVELY TO QUESTIONS ON THE PRETREATMENT SENSITIVITY QUESTIONNAIRE.

Question	Active DSA Group Response (%) (n = 22)	Placebo DSA Group Response (%) (n = 18)
1. Do your teeth normally get sensitive after a tooth cleaning?	50	28
2. Are your teeth normally sensitive to hot and cold?	32	28
3. Have you ever used a toothpaste or fluoride specifically to control sensitive teeth?	14	22
4. Do you use carbonated drinks such as Coke, Pepsi, or Fresca on a daily basis? If so, what kind and how much?	0	22
5. Do you eat citrus fruits or drink citrus fluids on a daily basis? If so, what kind and how much?	5	0
6. Have you ever had a facial Class V restoration placed to control gingival sensitivity of a tooth? If so, which teeth?	32	11

DSA = desensitizing agent.

whitening. The placebo was the same formulation as UltraEZ but without the DSAs (3% potassium nitrate and 0.11% by weight fluoride ion). The whitening solution was a 10% carbamide peroxide whitening solution (Opalescence™, Ultradent Products Inc.). Participants were instructed to place enough treatment solution and whitening material to fill the tray, with minimal excess. Post treatment, participants were followed up for 1 week, during which time they used neither trays nor solutions. Throughout the study, participants completed a daily log to record their perceptions of TS and the time they spent wearing the tray with the whitening solution. A two-tailed Fisher exact test was used to determine whether the two DSAs differed in preventing TS.

RESULTS

The results of our study showed that the participants who used an active DSA on a daily basis reported less TS than did participants using a placebo. The difference was statistically significant ($p = .027$) using the two-tailed Fisher exact test. Forty patients who were believed to be at risk for developing TS during NGVB were enrolled in the study (35 females and 5 males). Twenty-seven participants (68%) completed the 14 days of treatment. Five participants (12.5%) quit the study owing to TS and/or GI (1 participant in the active group and 4 in the placebo group). Eight participants (20%) quit for other reasons. Average days of treatment were 12.5 for the active group and 11 for the placebo group. There were no significant differences between the two groups with respect to days of treatment. Forty-one percent of the active group had at least 1 day of TS during treatment compared with 78% of the placebo group ($p = .027$). Twenty-five percent of the males in the active group and 44% of the females reported TS compared with 100% of the males and 76% of the females in the placebo group. See Tables 2 and 3 for a presentation of study findings.

DISCUSSION

In our NGVB study the daily application of an active DSA was found to prevent or decrease TS in an at-risk population. The at-risk population included participants who answered yes to at least one question on a pretreatment sensitivity questionnaire (see Table 1). From a previous NGVB pilot project, it was concluded that the generic use of a pretreatment DSA in a general population was not effective in preventing TS during NGVB.[28] However, the pretreatment DSA did benefit those participants answering yes to at least one question on the pre-

TABLE 2. PARTICIPANT DEMOGRAPHICS AND STUDY RESULTS.*

	Active Participants	Placebo Group	Statistical Significance
Study sample: $N = 40$	22	18	—
Females	18 (82%)	17 (94%)	—
Males	4 (18%)	1 (6%)	—
Average age (range 19–53 yr)	25	26	NS
Average hours worn (range)	82 (33–116)	80 (26–112)	NS
Preexisting thermal sensitivity	7 (32%)	5 (28%)	NS
Sensitivity with guard alone	1 (4.5%)	2 (11.0%)	ND
Tooth sensitivity during study	9 (41%)	14 (78%)	$p = .027$
Average days of sensitivity	7.0	4.0	NS
Range of days with sensitivity	1–13	1–9	ND
Treatment days with recorded tooth sensitivity	23%	26%	NS
Gingival recession	2	3	ND
Gingival recession and sensitivity	1	3	ND
Post-treatment sensitivity	1 (4.5%)	3 (17%)	ND
Average days of post-treatment sensitivity	7	3.3	ND

ND = not determined; NS = not statistically significant.
*When comparing those using a desensitizing agent (active participants) against those receiving a placebo.

TABLE 3. PARTICIPANTS REPORTING TOOTH SENSITIVITY DURING STUDY AND ANSWERING YES TO QUESTIONS.*

Positive Response	Active Participants	Placebo Group
One question	42% (5/12)†	60% (3/5)
One or two questions	39% (7/18)	70% (7/10)
Two or more questions	40% (4/10)	92% (12/13)
Question 2‡	40% (2/5)	82% (9/11)
Questions 4 and 5	44% (8/18)	76% (13/17)
Questions 2 and 4 or 5	33% (1/3)	80% (8/10)
Question 6	29% (2/7)	100% (2/2)
Questions 3 and 6	25% (2/8)	83% (5/6)

*On a questionnaire concerning their risk potential for developing tooth sensitivity during nightguard vital bleaching. Those using a desensitizing agent (active participants) are compared with those receiving a placebo.
†Denominator represents number answering yes to question; numerator represents number who answered yes and experienced tooth sensitivity.
‡See Table 1 for specific questions.

treatment sensitivity questionnaire. It is believed by the authors that this study is the first in which only participants at risk for developing TS were selected to evaluate the effectiveness of a prescribed pretreatment application of a DSA in preventing or decreasing TS during NGVB. Previously, the approach had been to deal with TS after it had occurred by prescribing a DSA, or to prophylactically treat TS, as if everyone would experience it during NGVB, by prescribing a whitening solution containing a DSA.

It is not fully understood why some patients experience TS during NGVB and others do not. TS caused by NGVB is most certainly multifactorial and not solely related to the whitening solution. As reported by three participants (7.5%) in our study, the guard alone caused TS. This has also been reported in other studies using different whitening solutions and tray materials.[21,27] Three participants also experienced TS during the 1-week active whitening phase of our study: one in the active DSA group and two in the placebo group. In the post-treatment period, only one participant reported TS. Although not confirmed statistically, it was suspected that the active DSA itself could cause TS in some participants owing to its hypertonic nature when compared with plasma. The one participant in the active group who quit the study because of severe TS while using the active DSA reported no preexisting TS. At the 1-week post-treatment examination, that participant reported that all TS had resolved soon after stopping treatment. After the study the patient successfully treated her teeth with only the active whitening solution and did not experience any TS.

Since it is documented that the same 10% whitening solution used in our study has caused TS in 55 to 80% of participants in other clinical trials, we decided against having a third group of participants use only the whitening solution.[5,17,21–23,29] Therefore, the group of participants receiving the placebo DSA was the control group. The percentage of participants in the placebo group reporting TS in our study was similar to that reporting sensitivity for the same whitening solution. In our study it was impossible to detect whether the placebo solution had caused any TS.

On average, the group receiving the active DSA benefited from its daily application. However, for the participants who experienced TS, the average days of TS for the active DSA group was 1.75 times that of the placebo DSA group. The percentage of treatment days participants recorded TS was similar. Why this occurred is unclear, but the active treatment days, hours worn, and number of those completing treatment were higher in the active group than in the placebo group. Additionally, it is unclear what effect the active DSA had on causing TS. It has been advocated that sustained use over several weeks may be needed to best benefit from the effects of fluoride and

potassium nitrate, but this was not done in our study.

Thus far, the only predictors documented in the literature for developing TS during NGVB have been patients with a history of thermal sensitivity pretreatment, gingival recession on the teeth being treated, and a treatment regimen of more than one time per day (usage pattern).[15,17] In our study the usage pattern was the same for both groups and thus was not a variable for evaluating participants. With respect to gingival recession, owing to the small number of participants presenting with gingival recession (two in the active and three in the placebo group), statistical differences were not tested. Clinically one patient in the active group and all three in the placebo group experienced TS during the whitening procedure.

In our study, of those responding yes to question 2 concerning pretreatment thermal sensitivity, 92% experienced TS during whitening in the placebo group, whereas only 40% using the active DSA reported TS. This is consistent with what has been reported in the literature with respect to preexisting thermal sensitivity being a risk factor for developing TS during NGVB.[17] The use of DSA did not eliminate TS during whitening, but it did decrease the number of participants reporting TS. The difference was statistically significant. No attempt was made to quantify the severity of sensitivity. The use of a DSA also appeared to benefit those participants reporting the use of toothpaste or fluoride or having a Class V restoration placed to control sensitivity of a tooth (questions 3 and 6). Likewise, participants consuming acidic beverages or fruits (question 4 and 5) also benefited from a daily DSA regimen.

CONCLUSIONS

TS associated with NGVB is an unpredictable and common occurrence. We in the dental profession must strive to identify those at risk for TS or other side effects during whitening, as well as knowing when to prescribe chemotherapeutic agents to decrease or prevent side effects, so that patients can treat their teeth with as little discomfort as possible. The use of DSAs in NGVB has shown promise but needs further evaluation. Our study showed that the daily application of an active DSA in a population at risk for TS during NGVB prevented or decreased TS when compared with a placebo. Additionally, the development and use of a risk assessment questionnaire to aid the dentist in determining who might be at risk for developing TS during whitening treatment certainly has merit.

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REFERENCES

1. Haywood VB, Heymann HO. Nightguard vital bleaching. Quintessence Int 1989; 20:173–176.
2. Curtis JW, Dickinson GL, Downey MC, et al. Assessing the effects of 10 percent carbamide peroxide on oral soft tissue. J Am Dent Assoc 1996; 127:1218–1223.
3. Curtis JW Jr, Dickinson GL, Myers ML, Russell CM. Evaluating the effects of a dentist-supervised, patient-applied carbamide peroxide bleaching agent on oral soft tissues. J Esthet Dent 1995; 7:18–25.
4. Haywood VB, Leonard RH. Nightguard vital bleaching removes brown discoloration for 7 years: a case report. Quintessence Int 1998; 29:450–451.
5. Haywood VB, Leonard RH, Nelson CF, Brunson WD. Effectiveness, side effects, and long-term status of nightguard vital bleaching. J Am Dent Assoc 1994; 125:1219–1226.
6. Heymann HO, Swift EJ Jr, Bayne SC, et al. Clinical evaluation of two carbamide peroxide tooth-whitening agents. Compend Contin Educ Dent 1998; 9:359–376.
7. Leonard RH, Haywood VB, Dickinson GL, et al. Nightguard vital bleaching of tetracycline stained teeth: 54 months post-treatment. J Esthet Dent 1999; 11:265–277.
8. Ouellet D, Los S, Case H, et al. Double-blind whitening night-guard study using ten percent carbamide peroxide. J Esthet Dent 1992; 4:79–83.

9. Russell CM, Dickinson GL, Johnson MH, et al. Dentist-supervised home bleaching with ten percent carbamide peroxide gel: a six-month study. J Esthet Dent 1996; 8:177–182.

10. Reinhardt JW, Eivins SE, Swift EJ Jr, et al. A clinical study of nightguard vital bleaching. Quintessence Int 1993; 24:379–384.

11. Scherer W, Palat M, Hittelman E, Putter H, Cooper M. At-home bleaching system: effect on gingival tissue. J Esthet Dent 1992; 4:86–89.

12. Schulte JR, Morrissette DB, Gasior EJ, Czajewski MV. The effects of bleaching application time on the dental pulp. J Am Dent Assoc 1994; 125:1330–1335.

13. Sterret J, Price RB, Bankey T. Effects of home bleaching on the tissues of the oral cavity. J Can Dent Assoc 1995; 61:412–420.

14. Haywood VB, Caughman WF, Frazier KB, Myers ML. Tray delivery of potassium nitrate–fluoride to reduce bleaching sensitivity. Quintessence Int 2001; 32:105–109.

15. Jorgensen MG, Carroll WB. Incidence of tooth sensitivity after home whitening treatment. J Am Dent Assoc 2002; 133:1076–1082.

16. Leonard RH. Efficacy, longevity, side effects, and patient perceptions of nightguard vital bleaching. Compend Contin Educ Dent 1998; 19:686–698.

17. Leonard RH, Haywood VB, Phillips C. Risk factors for developing tooth sensitivity and gingival irritation associated with nightguard vital bleaching. Quintessence Int 1997; 28:527–534.

18. Pohjola RM, Browning WP, Muckman ST, Downey MC. Sensitivity and tooth whitening agents. J Esthet Restor Dent 2002; 14:85–91.

19. Haywood VB. Extended bleaching of tetracycline-stained teeth: a case report. Contemp Esthet Restorative Pract 1997; 1(1):14–21.

20. Haywood VB. Current status and recommendations for dentist-prescribed, at-home tooth whitening. Contemp Esthet Restorative Pract 1999; 3(1):2–9.

21. Leonard RH, Bentley C, Eagle JC, Garland GE, Knight MC, Phillips C. Nightguard vital bleaching: a long-term study on its efficacy, shade retention, side effects, and patients' perceptions. J Esthet Restor Dent 2001; 13:357–369.

22. Matis BA, Mousa HN, Cochran MA, Eckert GJ. Clinical evaluation of bleaching agents of different concentrations. Quintessence Int 2000; 31:303–310.

23. Matis BA, Cochran MA, Eckert GJ, Carlson TJ. The efficacy and safety of a 10% carbamide peroxide bleaching gel. Quintessence Int 1998; 29:555–563.

24. Andreana S, Ciancio SG, Mather ML. Clinical evaluation of bleaching gels on patients with sensitive teeth. J Dent Res 2000; 79:201. (Abstr)

25. Kihn P, Litkowski L, Strassler H. Clinical evaluation of 10% carbamide with potassium nitrate. J Dent Res 2000; 79:439. (Abstr)

26. Munoz CA, Dunn JR, Sy-Munoz J, Li Y, Kim J. Clinical evaluation of a combined in office and at home applied bleaching. J Dent Res 1999; 78:144. (Abstr)

27. Leonard RH, Garland GE, Eagle JC, Caplan DJ. Safety issues when using a 16% carbamide peroxide whitening solution. J Esthet Restor Dent 2003; 14:359–367.

28. Smith LR, Leonard RH, Eagle JC, Murdock WC, Garland GE, Caplan DJ. Efficacy of desensitizing gel in reducing tooth sensitivity during whitening. J Dent Res 2001; 80:247. (Abstr)

29. Tam L. Clinical trial of three 10% carbamide peroxide bleaching products. J Can Dent Assoc 1999; 65:201–205.

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