ORIGINAL ARTICLE

A TRIPLE-BLIND RANDOMIZED CLINICAL TRIAL COMPARING THE EFFICACY OF A DESENSITIZING AGENT USED WITH AN AT-HOME BLEACHING TECHNIQUE

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ABSTRACT

Purpose
The aim of this study was to determine whether a sustained-release desensitizing gel containing 3% potassium nitrate and 0.11% fluoride ion reduces the risk of tooth sensitivity without compromising the effectiveness of bleaching treatment.

Methods
Thirty-two patients were randomly assigned to 2 experimental groups: desensitizing gel and placebo. The desensitizing gel or placebo was applied for 30 minutes prior to the at-home vital bleaching gel application. A nightguard dental bleaching treatment (NGVB) using a 16% carbamide peroxide gel was performed for 6 hours over a 3-week period. Patients recorded their tooth sensitivity daily using a 5-point Numeric Rating Scale (NRS). Whiteness index measurements were obtained using a dental spectrophotometer on the upper canines (right and left).

Results
The overall risk of sensitivity was 37.5% in the desensitizing gel group compared to 87.5% in the placebo group, yielding a relative risk of 0.42 (95% CI 0.22-0.82), showing a statistically significant difference between the groups ($P < .05$). During the first week, patients in the placebo group exhibited a higher risk of experiencing mild sensitivity. However, no statistically significant differences in sensitivity intensity were observed overall or during the second and third weeks ($P > .05$). Regarding color change, the mean difference between groups in the first week was 5.25 (-0.22 to 10.71), in the second week 4.25 (-2.56 to 11.02), and in the third week 2.55(-4.11 to 9.22). No statistically significant differences were found between the groups at any time point ($P > .05$).

Conclusions
The use of a sustained-release desensitizing gel containing 3% potassium nitrate and 0.11% fluoride ion for 30 minutes prior to the bleaching agent effectively reduced sensitivity during at-home bleaching procedures. Furthermore, the desensitizing gel did not impact the effectiveness of the at-home bleaching treatment.

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KEYWORDS
At-home bleaching, Desensitizing agents, Randomized clinical trial., Tooth bleaching, Tooth sensitivity

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INTRODUCTION

When patients' primary aesthetic concern is the shade of their teeth, bleaching becomes the treatment of choice and one of the most requested procedures.[1,2] It preserves tooth structure and causes little to no permanent physical change, making it both safe and effective.[3-5] Various techniques and products are available for bleaching vital teeth, but the most used and effective method is at-home bleaching with individualized trays and low concentrations of carbamide peroxide (CP) or hydrogen peroxide (HP) .[6-10] In Europe, regulations allow the use of products containing 0.1-6% HP and 0.3%-17% CP.[11]

Despite proper treatment administration, tooth sensitivity (TS) during or after bleaching is one of the most frequent side effects.[3,12-15] A systematic review by de Geus et al. [16] indicates that there are no significant differences in the risk or intensity of TS between in-office and at-home bleaching procedures. However, these findings should be interpreted with caution, as factors such as application duration, frequency of bleaching sessions, and the concentration of bleaching agents are associated with TS.[8,16,17] Nonetheless, there seems to be a trend indicating a higher risk and intensity of TS linked to in-office compared to at-home bleaching procedures.[16] In 2016, Rezende et al [18] published a review analyzing data from 11 randomized controlled trials (RCTs), showing that the risk of TS following at-home bleaching treatment was approximately 51%.

Although TS is typically mild and temporary, it can sometimes result in severe and intense pain, forcing patients to discontinue treatment.[12,19] This type of TS occurs when peroxides penetrate the enamel and dentin, reaching the pulp and initiating an inflammatory response that leads to vasodilation and pain.[20]

A meta-analysis published by Wang et al. [21] in 2015 demonstrated that topical desensitizing agents containing potassium nitrate and/or fluoride reduce the risk of TS. A more recent meta-analysis by Martini et al [22] in 2021 confirmed the beneficial effects of potassium nitrate in reducing the risk and severity of TS. However, the clinical significance of these findings remains debatable, as they represent small effect sizes. Most randomized controlled trials (RCTs) included in this analysis evaluated the desensitizing effects of these agents during in-office bleaching treatments, with only 2 studies focusing on their efficacy in at-home treatments. Outcomes varied among studies on in-office bleaching; several trials [23-27] reported the desensitizing efficacy of potassium nitrate, while others [28-31] found no statistically significant differences between experimental and control groups. A similar pattern emerged in the 2 studies employing at-home bleaching techniques. Leonard et al.[32] found statistically significant differences when the desensitizing gel was applied for 30 minutes before the bleaching treatment. In contrast, Kose et al.[33] observed no significant differences in prevalence and intensity between groups ($P > .5$) when the gel was applied for just 10 minutes, although individuals in the placebo group experienced greater TS. Further research is needed to assess the efficacy of desensitizing agents in conjunction with at-home bleaching treatments.

In this study, a sustained-release gel containing 3% potassium nitrate and 0.11% fluoride ion will be tested. According to the manufacture's recommendations, application duration varies depending on patient conditions and clinician guidance, ranging from 15 minutes to 1 hour. The desensitizing gel's viscous and adhesive properties allow it to form a thin layer over the teeth, effectively sealing the surface. Potassium nitrate penetrates the dentinal tubules, where potassium ions create ionic barriers around the pulp. The increase in these ions causes sustained depolarization of the nerve, thereby reducing the activity of the pulp nerve fibers.[21,34] Meanwhile, fluoride blocks exposed dentin tubules by precipitating calcium fluoride crystals or fluoroapatite crystals, which may reduce fluid movement within the pulp and inhibit the transmission of stimuli .[35]

The primary objective of this study is to evaluate the effectiveness of a sustained-release desensitizing gel containing 3% potassium nitrate and 0.11% fluoride ion in reducing TS during bleaching treatment, while also assessing tis impact on the degree of tooth bleaching. The following null hypotheses were tested: (1) the use of a sustained-release desensitizing gel containing 3% potassium nitrate and 0.11% fluoride ion will not affect the absolute risk of TS; and (2) the use of this desensitizing gel will not affect the shade change following at-home bleaching.

MATERIAL AND METHODS

Ethical Approval and Protocol Registration

This triple-blind clinical trial was approved by the Galician Research Ethics Committee of SERGAS with registration code 2022/491. Its protocol was registered at ClinicalTrials.gov under the registration number NCT06371092. The study was conducted at the Faculty of Dentistry of Santiago de Compostela during February and March 2023. It was designed and carried out in accordance with the Consolidated Standards of Reporting Trials (CONSORT)[36] guidelines and the World Medical Association's Declaration of Helsinki. All participants received a trial information sheet and provided written informed consent.

Trial Design and Blinding process

A randomized, parallel, triple-blind clinical trial was designed with 2 study groups.

Neither the participants, outcome assessors, nor data analysts were aware of the group assignments. An independent

researcher managed the randomization and allocation concealment processes, as well as prepared syringes containing either the desensitizing agent or the placebo. This researcher was the only individual who knew the allocation for each patient throughout the study. The syringes were identical in appearance and labeled as A and B, with only the researcher aware of which letter corresponded to each substance. Patients were assigned unique identification numbers, and individual plastic bags containing personalized trays and syringes (both the bleaching agent and either the desensitizing agent or placebo) were prepared according to the predetermined randomization process. This setup ensured that both the operator and the participant remained blinded to the contents of the syringes when the bags were distributed. Additionally, the data analyst received a fully anonymized dataset, with no knowledge of the identity of the gels corresponding to A or B, thus preserving the study's blinding.

Recruitment of Volunteers and Eligibility Criteria

Patients from the Faculty of Dentistry interested in tooth bleaching treatment were informed about the study and invited to participate. Eligible patients had to meet several criteria: be over 18 years old, have no oral or systemic pathology, be periodontally healthy (as defined by Silness and Löe plaque index <1 [37]), exhibit no gingival recession or root dentin exposure, have no cavities, and present with a tooth shade of the upper canines of A2 or darker, as measured with a shade guide (Classical A1-D4 shade guide; VITA Zahnfabrik). Exclusion criteria included individuals with adhesive restorations or prostheses in the anterior region (maxilla and mandible), those with enamel or dentin alterations, prior hypersensitivity, smokers, pregnant women, or participants who had undergone prior bleaching treatment.

Sample Size Calculation

The sample size was determined based on data from of a previous study where the absolute risk of TS in the placebo group was reported as 78%.[32] Assuming a minimum expected effect size of 37%, with an alpha risk of 5% and a power of 80%, and adding 20% more subjects for possible losses, a total of 32 patients (16 per group) were needed. Calculated using IBM SPSS (SPSS Inc., Chicago, IL, USA) for Mac, v29.0 with the use of the !NSize.sps macro.[38]

Random Sequence Generation and Allocation Concealment

Randomization and allocation concealment were conducted by a researcher not involved in the study's implementation. Computered-generated block randomization was performed using IBM SPSS (SPSS Inc., Chicago, IL, USA) for Mac, v29.0, employing the !RNDSEQ.sps macro.[39] Participants were allocated in blocks of 4, and the researcher employed sequentially numbered, opaque sealed envelopes (SNOSE) to determine each patient's initial group assignment. After the screening visit, the allocation assignment was revealed by opening the envelope.[40] The researcher retained custody of the envelopes until the end of the study and did not disclose their contents until after the data analysis was completed.

Study Intervention

At the screening visit, a general examination was performed on all patients, including bitewing X-rays to check for interproximal caries and a dental prophylaxis (scaling and polishing) to remove extrinsic stains. Alginate impressions of both arches were taken (Orthoprint; Zhermack), cast in plaster (Elite Model Fast; Zhermack), and used to fabricate a 1-mm thick individualized soft upper and lower bleaching tray (Mouthguard 040; Dentaflux). The bleaching trays were trimmed 1-mm above the gingival margin and prepared with reservoirs in accordance with the manufacturer's instructions. A custom position-finder was also created for each patient to ensure consistent measuring at the same location on each tooth with the spectrophotometer.[41] The custom tray position-finder was made using a 4-mm thick transparent plastic sheet and was used at each visit (Mouthguard 150; Dentaflux).

At the next visit (week 0), each patient received a sealed plastic bag containing their personalized bleaching trays, one syringe of bleaching agent (Opalescence 16% PF; Ultradent Products, Inc.) and 2 syringes of either desensitizing gel (UltraEZ; Ultradent Products, Inc.) or placebo, based on their predetermined group assignment. The desensitizing gel is a sustained-release, viscous, sticky, odorless, and colorless formulation containing 3% potassium nitrate, 0.11% fluoride ion, glycerol, and sodium hydroxide. The placebo was similar in appearance and components to the desensitizing agent but without the active desensitizing components. They were dispensed into identical syringes, labeled A and B.

The bleaching trays were tried in to assess proper fit and retention. Nightguard vital bleaching (NGVB) was performed using 16% CP for both arches was simultaneously. All patients received detailed instructions on how to apply the gels, the amounts to use, and how to clean their trays. To standardize oral hygiene procedures throughout the study, participants were provided with a toothbrush and toothpaste (Colgate Total Original; Colgate Oral Pharmaceuticals). Participants were instructed to brush their teeth before applying the desensitizing agent/placebo to their trays. They were advised to place a drop of the desensitizing agent/placebo on each tooth from premolar to premolar and wear the trays for 30 minutes. Afterward, they rinsed the trays with cold water, brushed their teeth again to remove any remaining desensitizing/placebo, applied the bleaching agent (from premolar to premolar), and wore the trays overnight (for 6 hours). According to Haywood, for NGVB, the trays should

be worn overnight since the bleaching material is active for 4-10 hours[42]; in this study, participants were instructed to wear the trays for 6 hours, which is the maximum time recommended by the manufacturer. This process was repeated daily for 3 weeks. All patients received written instructions and a sensitivity recording sheet.

After the first week of treatment, shade evaluations were conducted, and one syringe of bleaching agent and 2 syringes of desensitizing/placebo were administered. Another shade evaluation and material delivery occurred after the second week. Finally, in the third week of treatment, the final shade evaluation was performed, and the sensitivity recording sheets were collected.

Tooth Sensitivity

All patients received a sensitivity recording sheet and were instructed to complete it daily throughout the 3-week treatment period. General sensitivity levels were assessed using a 5-point Numeric Rating Scale (NRS) (0 = no sensitivity; 1 = mild, slight discomfort; 2 = moderate, greater discomfort that does not interfere with daily life; 3 = considerable, much greater discomfort, leading to the avoidance of certain food and beverages; and 4 = severe, where the patient is forced to stop the bleaching treatment).[8,14,23,24,28,41] Patients selected the numeric value that best represented their level of TS.

For statistical analysis, the daily data recorded during each week of the treatment period was combined, as no significant differences were observed (data not shown). Patients who reported a score of 0 throughout the treatment were classified as not experiencing bleaching-induced TS, while those who reported any other score were considered to have TS. This dichotomization enabled the calculation of the absolute risk of TS. For data analysis, the highest sensitivity score recorded at each assessment point was used. Sensitivity outcomes were categorized into 2 groups: absolute risk of TS, reflecting the percentage of patients reporting TS (first week, second week, third week, and overall), and TS intensity (first, second, third week, and overall).

Shade Evaluation

Two evaluators measured tooth shades using a calibrated spectrophotometer (Easyshade V; VITA Zahnfabrik) before each evaluation. The mid-cervical point of the maxillary canines (right and left) served as the reference for color change. To determine the overall color change for each patient, the average of both canines was calculated.

To standardize the measurement of objective color, a 4-mm custom position-finder was created (Mouthguard 150; Dentaflux).[41] An access hole was made in the vestibular region at the mid-cervical point (2 mm from the cervical margin) of each tooth being studied, using a 6-mm external diameter trephine similar in size to the active tip of the spectrophotometer. The parameters *L (Lightness), *a, and *b were recorded.

Color measurements were taken at different points during the bleaching treatment. Week 0 (baseline, before treatment), week (7 days after the start of treatment), week 2 (14 days after the start of treatment), and week 3 (21 days after the start of treatment).

To calculate the color change between the initial visit and the evaluations at the first, second, and third weeks of treatment, the White Index for dentistry (WID) was used, computed using the following formula[43]: WID =0.511L* - 2.324a* - 1.100b*.

Statistical Analysis

All statistical analyses were conducted using IBM SPSS (SPSS Inc., Chicago, IL, USA) for Mac, v29.0. Normality was assessed through descriptive statistics, visual inspection (Q-Q plots, histograms, and boxplots), and the Saphiro-Wilk normality test (for samples <50 subjects). A significative level of 5% was applied to all tests.

Missing data due to nonattendance were addressed using the last available observation, a conservative method that reduces potential bias.

To compare the absolute risk of TS between groups, an intergroup analysis was conducted using the Pearson's Chi-square test for each time point (Week 1, Week 2, Week 3) and for the overall treatment period. Relative risk and 95% confidence intervals (CIs) were also calculated. The Cochran test was employed to evaluate changes in tooth sensitivity over time within each group.

Since TS intensity data were non-normal distributed, the analysis of intensity levels between groups was conducted using the Lineal-by-linear association and Fischer's exact test, with Bonferroni-adjusted p-values for multiple comparisons across intensity ranges for each week and overall.

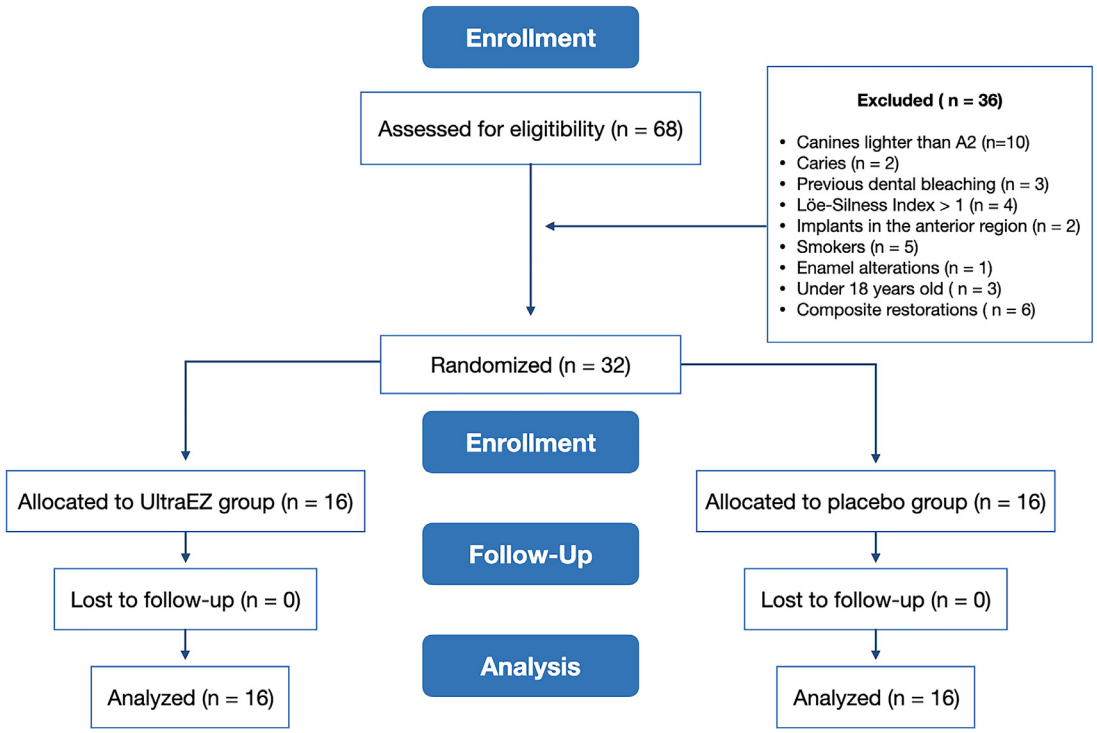
The change in the White Index for Dentistry (ΔWID) was analyzed using repeated measures ANOVA with pairwise comparisons adjusted by the Bonferroni correction.

RESULTS

Characteristics of the Included Participants

The study flow diagram is presented in Figure 1 A total of 68 participants were initially evaluated, with 32 participants who met all inclusion criteria selected for the study. All participants completed each phase of the trial, with no dropouts. In the placebo group, 75% of participants were women, with a mean age of 29.06 ±10.98 years. In the desensitizing gel group, 62.5% were women, with a mean age of 30.94 ±10.78

Figure 1. CONSORT flow diagram.



years. The mean WID was 8.20 ±7.48 in the placebo group and 5.53 ± 13.22 in the desensitizing group. No statistically significant differences were found between the groups in terms of age, sex, or baseline WID. None of the participants reported tooth sensitivity prior to bleaching, and no significant harms or unintended were observed in either group.

Tooth Sensitivity

The absolute risk, relative risk, and number of patients experiencing tooth sensitivity during each week and in the overall assessment are shown in Table 1. Overall, the desensitizing gel group exhibited a statistically significant reduction in TS compared to the placebo group ($P = .003$). Participants using the desensitizing gel had a 58% lower risk (95% CI 18%-78%) of experiencing TS compared to those in the placebo group.

Intensity of Tooth Sensitivity

The distribution of TS intensity in each group during week 1 is illustrated in Figure 2. At this time, 12.5% of patients in the placebo group and 68.8% in the desensitizing group reported no sensitivity. Mild sensitivity was observed in 43.8% of the placebo group and 12.5% of the desensitizing group. Moderate sensitivity was reported by 18.8% of the placebo group and 6.3% of the desensitizing group. Furthermore, 25% of patients in the placebo group and 12.5% in the desensitizing group reported considerable sensitivity, with no reports of severe sensitivity in either group. A statistically significant association was found between TS intensity levels and treatment groups ($P = .009$), with a significant association ($P = .04$) between the groups for mild sensitivity versus no sensitivity, indicating a higher risk of mild sensitivity in the placebo group.

Figure 3 presents the distribution of TS intensity in each group during week 2. At this point, 12.5% of placebo group patients and 62.5% of the desensitizing group reported no sensitivity. Mild sensitivity was reported by 43.8% of the placebo group and 18.8% of the desensitizing group. Moderate sensitivity was experienced by 43.8% of the placebo group and 12.5% of the desensitizing group. Considerable sensitivity was reported by 6.3% of the desensitizing group and no cases of severe sensitivity were reported in either group. A significant relationship between TS intensity and treatment groups was observed ($P = .03$), though no statistically significant associations were identified for individual intensity categories.

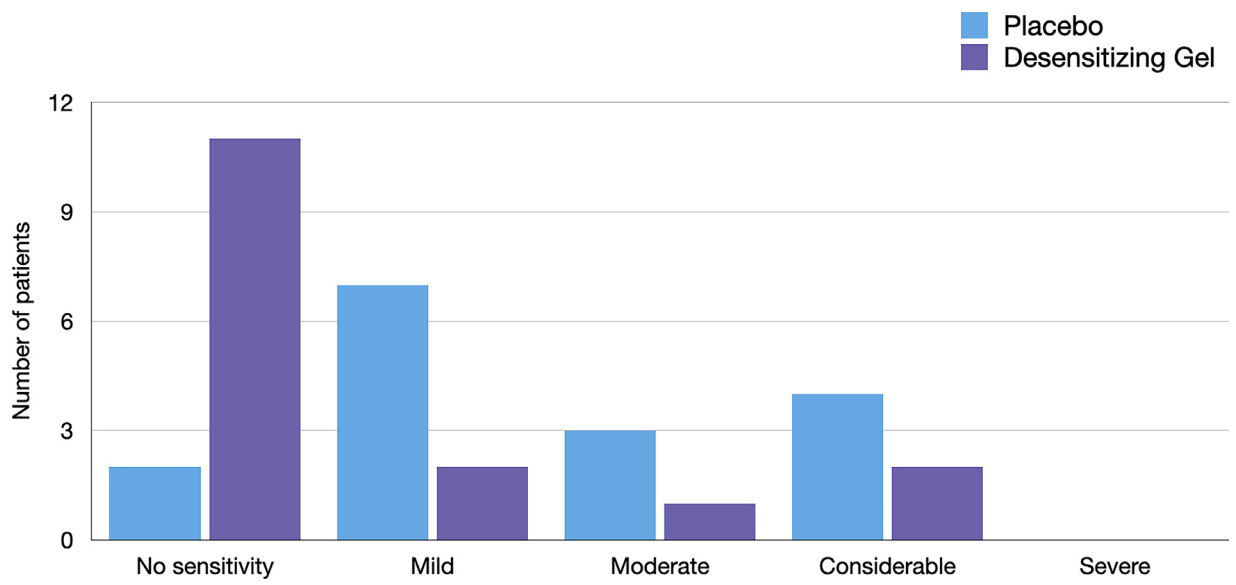
The distribution of TS intensity in week 3 is shown in Figure 4. At this time, 18.8% of patients in the placebo group and 62.5% in the desensitizing group reported no sensitivity. Mild sensitivity was noted in 56.3% of the placebo group

Table 1. Number of patients who experienced tooth sensitivity, absolute risk, and relative risk

Evaluation	Group	Tooth sensitivity (n)		Absolute risk (95% CI)	Relative risk (95% CI)
		Yes	No		
Week 1	Placebo	14	2	87.5% (63.9-96.5%)	0.36 (0.17-0.76)[a]
	Desensitizing	5	11	31.3% (14.2-55.6.5%)	
Week 2	Placebo	14	2	87.5% (63.9-96.5%)	0.42 (0.22-0.82)[b]
	Desensitizing	6	10	37.5% (18.5-61.4%)	
Week 3	Placebo	13	3	81.3% (93.4-56.9%)	0.46 (0.23-0.90)[c]
	Desensitizing	6	10	37.5% (18.5-61.4%)	
Overall	Placebo	14	2	87.5% (63.9-96.5%)	0.42 (0.22-0.82)[d]
	Desensitizing	6	10	37.5% (18.5-61.4%)	

N, number of patients; CI, confidence interval.
[a] Pearson Chi-square test *P* = .001.
[b] Pearson Chi-square test *P* = .003.
[c] Pearson Chi-square test *P* = .012.
[d] Pearson Chi-square test *P* = .003.

Figure 2. Intensity of tooth sensitivity. Week 1.



and 12.5% of the desensitizing group. Moderate sensitivity was reported by 12.5% of the placebo group and 6.3% of the desensitizing group. Considerable sensitivity was experienced by 12.5% of the placebo group and 18.8% of the desensitizing. No severe sensitivity cases were reported. No statistically significant relationship was found between TS intensity levels and treatment groups at week 3 (*P* = .32).

The overall distribution of TS intensity levels across the study is shown in Figure 5. In this assessment, 12.5% of the placebo group and 62.5% of the desensitizing group reported no sen-

Figure 3. Intensity of tooth sensitivity. Week 2.

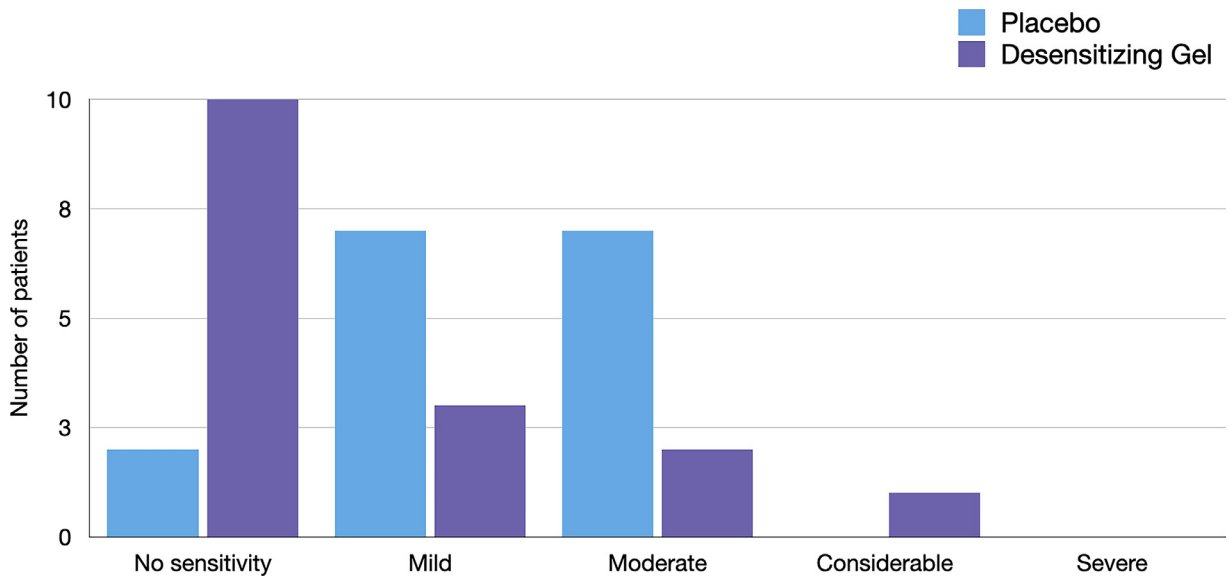
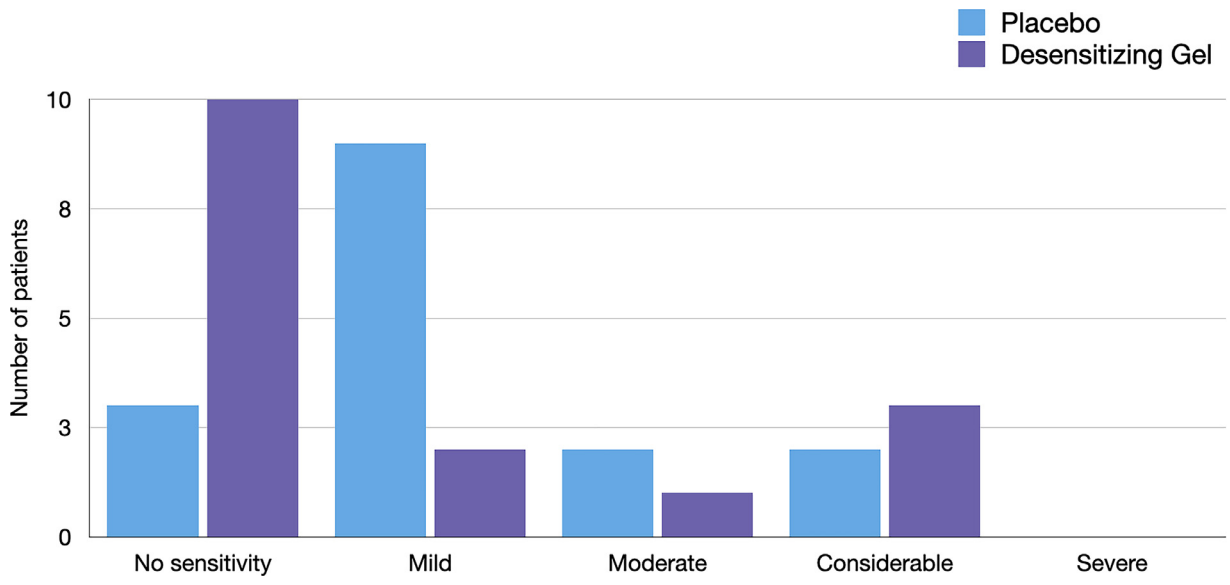


Figure 4. Intensity of tooth sensitivity. Week 3.



sitivity. Mild sensitivity was observed in 18.8% of the placebo group and 12.5% of the desensitizing group. Moderate sensitivity was experienced by 31.3% of the placebo group and 6.3% of the desensitizing group. Considerable sensitivity was reported by 37.5.5% of the placebo group and 18.8% of the desensitizing. No cases of severe sensitivity were observed in either group. A significant relationship between TS intensity levels and treatment groups was identified ($P = .01$), although no statistically significant associations were observed within specific sensitivity categories.

No significant differences in TS intensity were noted across the different time points for both groups ($P > .5$, data no shown).

Figure 5. Intensity of tooth sensitivity. Overall scenario.

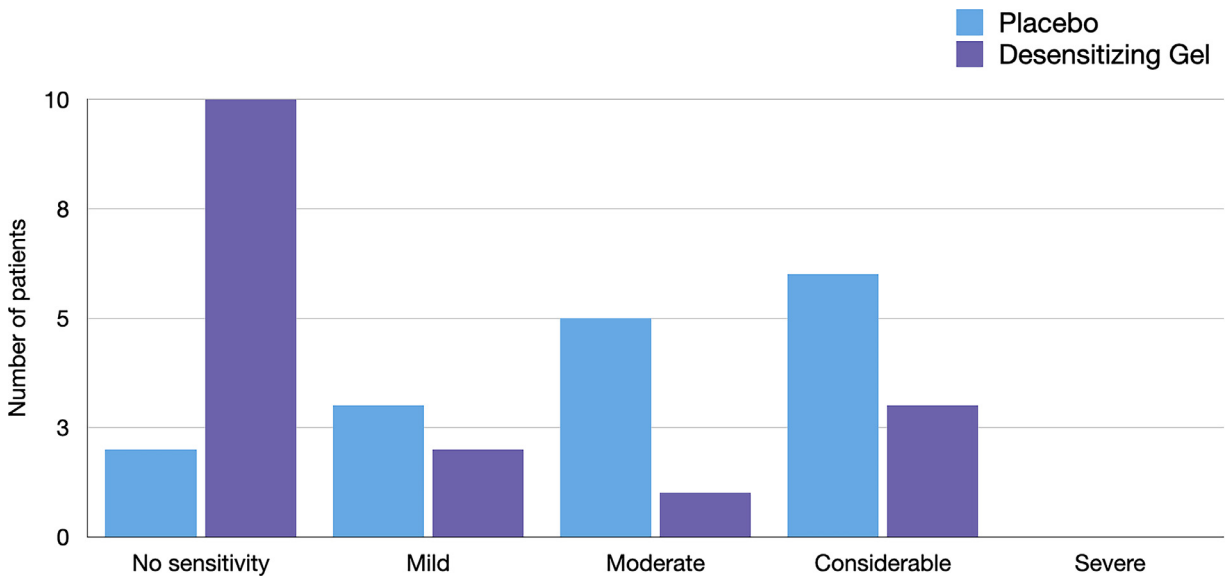


Table 2. Means and standard deviations of WID at different assessment periods

Evaluation	Groups		Mean difference (95% CI)	*P*-value[a]
	Placebo	Desensitizing		
First week	24.54 ±1.89	19.32 ±1.89	5.25 (-0.22 to 10.71)	.05
Second week	26.66 ±2.35	22.43 ±2.35	4.23 (-2.56 to 11.02)	.21
Third week	29.99 ±2.30	27.44 ±2.31	2.55 (-4.11 to 9.22)	.44

CI, confidence interval.
[a] ANOVA.

Shade Change

The means and standard deviations of WID for both the placebo and the desensitizing gel groups are summarized in Table 2. While no statistically significant differences were observed between groups at any assessment periods, both groups showed a statistically significant increase in WID over the course of the study ($P<.05$) (data no shown).

DISCUSSION

Tooth sensitivity is a well-documented side effect of hydrogen peroxide and carbamide peroxide based bleaching gels used in tooth bleaching procedures.[3,12-15] The sensitivity is multifactorial and remains difficult to fully prevent.[44] Several approaches have been suggested to mitigate bleaching-induced TS, including reducing the frequency and duration of treatment, using desensitizing pastes 2 to 3 weeks before or after treatment initiation, incorporating desensitizing agents into bleaching gels, or applying a desensitizing gel for 10 to 30 minutes prior to each session.[17,21,44,45]

It is worth noting that while many bleaching gels include desensitizing agents, these additives generally show limited effectiveness in reducing dental sensitivity.[35,46] Complementary topical applications of potassium nitrate and/or fluoride-based desensitizing agents, however, have shown effectiveness in reducing TS.[21,22] However, most studies supporting their efficacy focus on in-office bleaching protocols,[23-27,47] with relatively few RCTs evaluating their effects in at-home bleaching procedures.[32,33,48] This represents a gap in the literature, especially as at-home treatments grow in popularity.

Our study aimed to address this gap by evaluating the effectiveness of a sustained-release desensitizing gel containing 3% potassium nitrate and 0.11% fluoride ion for at-home bleaching treatment.

Desensitizing agents are classified by their mechanism of action into 2 main categories: neural desensitizers and dentinal tubule blockers.[49] Neural desensitizers, such as potassium nitrate, act by altering nerve cell activity, depolarizing the membrane, and reducing transmission of painful stimuli. Dentinal tubule blockers work by occluding open tubules, disrupting the hydrodynamics of dentinal fluid, and thereby preventing dentin sensitivity.[34,49] The potassium ions forms an ionic barrier around the pulp, leading to nerve depolarization and reducing the transmission of nerve impulses.[21,34] In contrast, fluoride ions function as tubule blockers, precipitating as calcium fluoride crystals on exposed dentin surfaces to seal tubules and block dentinal fluid movement, which alleviates sensitivity.[35]

In our study, the risk of TS in the placebo group reached 87.5%, significantly higher than average .[18] This elevated sensitivity could be attributed to the use of a 16% carbamide peroxide concentration in an at-home bleaching treatment with a prolonged application time of 6 hours. This concentration was chosen bases on prior studies evaluating bleaching agent efficacy and safety.[4,50,51] These conditions -high bleaching agent concentration and extended exposure- created an ideal scenario to challenge the desensitizing gel's effectiveness, establishing a rigorous baseline for efficacy. By creating this "worst-case scenario", we aimed to ensure that any reduction in TS was attributable to the gel, not incidental mild sensitivity.

In the desensitizing group, the risk of TS was significantly lower across assessment points. Notably, only one previous study has used the same desensitizing agent during an at-home bleaching protocol. Leonard et al. [32] applied a 10% carbamide peroxide gel alongside a desensitizing gel for 30 minutes and observed a significant difference in TS between groups, similar to our findings. Barcellos et al.,[48] who used a 0.11% sodium fluoride desensitizing agent for 30 minutes, also reported comparable results.

However, Kose et al. [33] used a 16% carbamide peroxide bleaching gel and a desensitizing agent with 5% potassium nitrate and 2% sodium fluoride for a shorter application time of 10 minutes. In their study, although there was a reduction in TS intensity, differences between groups were not statistically significant. This may be explained by the shorter application time; potassium nitrate can penetrate the pulp cavity within 5 minutes, but its efficacy increases with time and concentration.[52,53] Therefore, the longer application time in our study likely contributed to the more substantial TS reduction observed.

When assessing TS intensity, we found no statistically significant differences between groups. However, further analysis at each time point revealed that, during the first week, patients in the placebo group had a higher risk of mild sensitivity ($P < .5$). Despite the lack of significant intensity differences between visits, there was a gradual increase in TS as the weeks progressed, with a notable rise during the second week. Leonard et al.[32], who used the same desensitizing agent, did not evaluate TS intensity, highlighting the novelty of our study's assessment of both TS risk and intensity at different time points.

In addition, we aimed to confirm that using the desensitizing gel prior to bleaching would not compromise the bleaching efficacy. Various methods exist to assess shade changes. Traditionally, shade has been subjectively evaluated through visual inspection using shade guides because of its simplicity and quickness. However, this method is subjective and can be influenced by external factors such as the observer's own experience, visual fatigue, or variations in environmental lighting conditions.[25,54,55] In our study, shade was measured objectively using a dental spectrophotometer, which provides precise color measurements based on reflected light wavelengths. Spectrophotometers are also simple and easy to use, making them ideal for obtaining precise measurements.[56,57] For color data analysis, the Whiteness Index for Dentistry (WID), introduced in 2016, was employed. This index is derived from CIELAB chromatic coordinates and is used to calculate whiteness differences (ΔWID) in bleaching treatments, based on correlations with the visual perception of tooth-shaped shade tabs and dental materials. High positive WID values indicate greater whiteness, while low or negative values reflect lower whiteness.[43]

A meta-analysis by Martini et al. [22] suggest that potassium nitrate-based desensitizing gels do not interfere with bleaching efficacy. Potassium nitrate and bleaching agents both penetrate pulp tissue, and the small particle size of these agents allows them to move easily through enamel pores.[29,54] Potassium nitrate does not impede trans-enamel peroxide diffusion, as it and the peroxide molecules act through separate mechanisms of action.[22,28,54]

The week-by-week analysis of WID results shows that the placebo group exhibited slightly higher WID values compared to the desensitizing group. However, when examining the means and confidence intervals for each week, these differences were not clinically significant, and no statistically significant differences were observed between the groups ($P > 0.05$). The application of this desensitizer did not affect the change of tooth shade by at-home bleaching. To our knowledge, no previous study has evaluated whether the use of a sustained release desensitizing gel containing 3% potassium nitrate and 0.11% fluoride ion during an at-home bleaching treatment affects the bleaching efficacy. This study is the first to explore this aspect.

Few studies examining in-office bleaching have reported similar finding, suggesting no adverse effects on bleaching results.[47,54,58] These findings support that this desensitizing agent does not diminish bleaching efficacy.

Several methodological aspects warrant discussion. First, we used a 5-point NRS to assess TS. Although there is no consensus on the most accurate scale for pain evaluation,[59,60] the NRS is a simple, intuitive method that facilitates patient understanding, allowing them to effectively communicate discomfort. This scale has been widely used in various studies over the years to assess pain levels, demonstrating its reliability and practicality in clinical research.[8,14,23,24,28,41] Another notable aspect of this study is that color evaluation was performed on the canines rather than the incisors. This choice offered the advantage of simplifying patient recruitment, as it is challenging to find participants with incisors darker than A2 who meet inclusion criteria.[35] Other important methodological consideration is the small sample size. This can lead to increased variability and may not fully represent the broader population, potentially limiting the external validity of the results. Additionally, recruiting from a single dental institution may introduce selection bias, as the patient population at that institution may not reflect the diversity of other communities or regions. This could affect the applicability of our findings to different demographics, age groups, or individuals with varying dental conditions.

The main limitation of this study is the focus on a single desensitizing agent and concentration. We only evaluate the desensitizing effect and color interaction of this specific agent, and it is possible that varying potassium nitrate or fluoride concentrations, or additional additives, might yield different TS management outcomes. Additionally, the sample predominantly consisted of young adults, which could influence bleaching efficacy.[18] Tooth color is influenced by the characteristics of the dentin, which change with age. In older patients, increased deposition of hydroxyapatite crystal in the enamel reduces its permeability, potentially affecting the response to both bleaching and desensitizing agents.[61,62] This age-related difference in enamel and dentin properties may lead to variations in treatment outcomes across different age groups.

Consequently, further research is needed. Future studies should compare various desensitizing agents and concentrations to identify the most effective formulation for alleviating bleaching-induced TS. Expanding the study population to include a broader age range and other demographic variables may also enhance generalizability.

CONCLUSION

The application of a sustained release desensitizing gel containing 3% potassium nitrate and 0.11% fluoride ion for 30 minutes before the application of a 16% bleaching agent significantly reduced the risk of sensitivity in an at-home bleaching procedure. The topical application of this desensitizing agent did not compromise the effectiveness of the bleaching process.

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