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Comparison of the Efficacy of Sodium Fluoride Varnish, Diode Laser, and Potassium Nitrate in Reducing Post-Bleaching Sensitivity: A Clinical Trial

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Abstract

Introduction: Professional tooth bleaching has become very popular over the last few years. Tooth sensitivity usually follows tooth bleaching. This study compared the efficacy of sodium fluoride varnish, diode laser, and potassium nitrate in reducing post bleaching sensitivity.

Methods: The anterior teeth of 30 patients who met the inclusion criteria were subjected to OB with 35% hydrogen peroxide and subsequently divided into three equal groups according to the desensitization method (n=10). The desensitization methods included 5% sodium fluoride varnish, potassium nitrate, and a diod laser (800 nm). Tooth sensitivity was measured with the Visual Analogue Scale (VAS) immediately after OB, and at 24 and 48 hours after the desensitization process. ANOVA, paired t-test, Wilcoxon test, and Repeated Measures ANOVA tests were used to analyze the data. Statistical significance was set at $P<0.05$.

Results: Although all desensitization methods showed a significant reduction in post-bleaching sensitivity ($P<0.0001$), there was no significant difference between their effectiveness. ($P=0.544$). There were no significant differences at any time point.

Conclusion: All desensitization methods reduced post bleaching sensitivity, but there was no significant difference between them. Thus, the use of the desensitization technique depends on available equipment and clinical judgment.

Keywords: Tooth bleaching, Low-level laser therapy (LLLT), Dentin desensitizing agents, Visual analog scale (VAS)

Introduction

Tooth Bleaching is defined as brightening the tooth color compared to its natural shade. Among cosmetic methods, tooth bleaching is a conservative method that also achieves satisfactory results and has attracted patients' attention. Tooth bleaching is done through the oxidation of the organic components of the tooth structure by hydrogen peroxide and other reactive forms of oxygen.[1-2] In general, there are three basic methods of tooth bleaching: home bleaching, office bleaching (OB), and the use of over-the-counter tooth whitening products.[3,4] OB has advantages such as protecting soft tissue, being controlled by a dentist, whitening teeth faster, and eliminating the need for long-term use of trays. Still, the most important disadvantage of this method is the higher risk of tooth sensitivity compared to the home bleaching method.[5-7] According to studies, more than half of the patients undergoing OB probably experience increased post bleaching sensitivity[8-10] post bleaching sensitivity appears to be different from thermal or contact sensitivity, which is generally associated with exposed root dentin. post bleaching sensitivity generally occurs as a result of the functional characteristics of ion channels sensitive to chemicals called transient receptor potential ankyrin 1 (TRPA1).[11] These ion channels are associated with pain induced by oxidants such as hydrogen peroxide.

To minimize post bleaching sensitivity, the use of analgesics,[12] anti-inflammatory drugs,[13] antioxidants,[9] corticoids,[14] and narcotic drugs [12] has been suggested. Nonetheless, clinical studies indicate that the use of oral medications does not diminish the risk or severity of post bleaching sensitivity, as confirmed in a systematic review.[15] A promising approach to minimize post bleaching sensitivity is the use of local desensitizing materials [15-17] such as 5% potassium nitrate gel and 0.7-2% sodium fluoride.[18] A number of clinical trials have demonstrated that the use of toothpaste and fluoride-containing solutions on exposed root surfaces is very effective in controlling and treating dentinal sensitivity.[19] It seems that the recovery is the result of increasing the resistance of dentin to demineralization and also the blockage of the dentinal tubules.[1] The effectiveness of potassium nitrate in the treatment of dentinal sensitivity is significant (18). A review study conducted by Bartold PM (2006) showed that a 5% concentration of potassium nitrate in a low-abrasive toothpaste had the ability to reduce dentin sensitivity.[20]

Low-Level Laser Therapy (LLLT), such as Diode Laser, has recently been introduced as a desensitizing protocol, the

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mechanism of which is through the neuropharmacological effect. In this process, the production, secretion, and metabolism of endogenous effectors such as β-endorphin and bradykinin change the permeability of the nerve cell membrane and temporarily change the sensory axon ends, ultimately leading to a decrease in nerve transmission and thence preventing depolarization inside the pulp.[21, 22]

Until now, numerous studies have been conducted to investigate the available methods for reducing post bleaching sensitivity[17, 23] Nevertheless, sporadic studies have been conducted to simultaneously investigate and compare local desensitizing materials. Most previous studies have investigated a single desensitizing method or compared only two approaches for post bleaching sensitivity. However, to our knowledge, no randomized clinical trial has directly compared the efficacy of 5% sodium fluoride varnish, potassium nitrate, and diode laser (810 nm) within the same standardized bleaching protocol and follow-up period. Hence, this study compared the effectiveness of sodium fluoride varnish, diode laser, and potassium nitrate in reducing post bleaching sensitivity. The null hypotheses of the study were as follows: 1. Three desensitizing methods do not significantly reduce post bleaching sensitivity, and 2. Reduction in post bleaching sensitivity is not significantly different between the three desensitizing methods.

Methodology

This study was designed as a randomized, parallel-group, single-blind, descriptive-analytical clinical trial conducted in the Restorative Dentistry Ward of Yazd Dental School.

Sample Size and Participants

The sample size was determined pragmatically based on the limited availability of eligible patients at the Restorative Dentistry Department during the study period. Thirty patients who met the inclusion criteria and reported a post-bleaching VAS score above 30 mm were enrolled. No formal a priori power calculation was performed because the total number of eligible patients was restricted to those attending during the recruitment window.

Inclusion and Exclusion Criteria

The primary inclusion criteria of the study were as follows: 1. Age of over 18 years, 2. Having six upper or lower vital anterior teeth without caries and no buccal restoration, 3. Anterior teeth color A2 or darker based on the vita classic shade guide kit, 4. Not having undergone bleaching procedures previously, 5. Lack of tooth sensitivity to the cold in anterior teeth, 6. Absence of pregnancy or breastfeeding, 7. Absence of severe color change caused by medicine, fluorosis and pulp disease in anterior teeth, 8. Absence of severe wear in the anterior teeth, 9. Absence of gingival recession in the anterior region, 10. Absence of "class V" lesions in the anterior teeth, 11. Absence of exposed dentin in the anterior teeth or any other clinical condition that can change dental sensitivity, and 12. Reporting sensitivity of 30mm on the VAS after bleaching. Exclusion criteria of the study were: 1. Non-cooperation in reporting the level of sensitivity, and 2. Non-cooperation in treatment.

After admitting the patients requesting OB and explaining the objectives of the study and the implementation method, the patients entered the study. Having obtained informed consent, we determined the level of dental sensitivity using the Visual analogue scale (VAS). The VAS is a 10 cm line printed on a piece of paper, one end indicating "no pain" and the other end indicating "worst pain». The patient placed a cross mark (X) on the line to show the intensity of her/his pain, and then the distance between the x mark and the pain-free end was measured with a ruler, and the number obtained in millimeters was considered as the pain score. VAS scores were recorded without an external stimulus for the most sensitive of the 6 treated anterior teeth.

Bleaching Procedure

Subsequently, all patients underwent OB treatment using 35% hydrogen peroxide (Whiteness HP, FGM). After placing the rubber dam and drying the teeth, a light-cured gingival dam resin (FGM Top Dam, FGM Dental Group, Brazil) was applied with 4-6 mm height and 1.5-2 mm thickness on the 6 anterior teeth and cured for 20 seconds with a scanning movement of a light-cure device. In the next step, a layer of bleaching gel (Whiteness HP, FGM Dental Group, Brazil) was applied using a microbrush on the labial surface of 6 mandibular or maxillary anterior teeth. After 20 minutes, the gel was removed using a cotton roll, and the gel was applied again for another 20 minutes. Finally, the gel was removed using a cotton roll, and the teeth were irrigated. The gingival dam was removed, and immediately after bleaching, tooth sensitivity was evaluated on the VAS.

Randomization and Allocation

Thirty persons who reported a sensitivity of more than 30 mm on the VAS were randomly subjected to one of the three desensitization methods (N = 10). Randomization was performed in two steps. First, all participants were randomly assigned to three equal groups. Then, using a table of random numbers, a sequence was generated to allocate the treatment modalities; the first randomly selected number corresponded to the potassium nitrate gel group, the second to the sodium fluoride varnish group, and the third to the diode laser group. This ensured unbiased allocation of interventions.

Group 1: Treatment with Potassium Nitrate

Desensitizing gel containing 2% potassium nitrate (Desensibilize KF 2%, FGM Dental Group, Brazil) was applied on the labial surface of all bleached teeth using a microbrush with 2mm thickness. The gel remained inactive for 10 minutes, and then it was removed and the teeth were irrigated.

Group 2: Treatment with Fluoride Varnish

Group 2 (Fluoride Varnish): Following teeth isolation with cotton rolls, a 5% sodium fluoride varnish (Ariadnet, Iran)

was applied to the bleached surfaces. The varnish was left undisturbed for 4 minutes before removal.

Group 3 (Diode Laser)

The bleached teeth were isolated using cotton rolls. Treatment was performed using a diode laser (A.R.C. Laser, Nuremberg, Germany) with the following parameters: 800 nm wavelength, 100 mW output power, and continuous-wave mode. A 400 μm diameter fiber was used to deliver an energy density of 4 J/cm² per tooth. The irradiation was applied for 30 seconds per tooth at a distance of approximately 1 mm using a scanning motion. Protective eyewear was worn by both the operator and the patient throughout the procedure. The laser tip was placed at a 1-mm distance from the buccal surface perpendicular to the teeth and exposed teeth with a scanning motion.[24]

Outcome Assessment

Tooth sensitivity was measured on the VAS immediately, 24 hours, and 48 hours following the treatment. Longer follow-up times were not considered due to the transient nature of post-bleaching sensitivity, which typically resolves within a few days

To do so, after full explanation and training, the VAS questionnaire was delivered to the patient, and during a phone call, the patient was reminded to record the level of sensitivity, and then the questionnaire was received from the patient and the level of sensitivity was recorded.

Statistical Analysis

Data were imported into the computer and analyzed with SPSS17. The normality of data was evaluated using the Kolmogorov-Smirnov test. The data that were not normally distributed were analyzed by the non-parametric tests, Normality was assessed via the Shapiro-Wilk test. Differences were compared using paired t-tests, one-way ANOVA, and repeated-measures ANOVA, as appropriate. Statistical significance was set at $P<0.05$.

Results

Thirty persons who met the inclusion criteria were included in the present study. Eight (26.66%) patients were male, and 22 (73.33%) were female. The mean age of the participants was 26.53 years, in the range of 18-42 years. The normality of data was checked by the Kolmogorov-Smirnov test, and the result revealed that the data were normally distributed ($P>0.05$). According to two-way ANOVA, there was no statistically significant difference in sensitivity between the three groups immediately after OB ($P=0.419$), which revealed homogeneity of the studied groups before desensitizing treatment. The result of two-way ANOVA showed that the difference between the three desensitization methods was not statistically significant immediately, 24 hours, and 48 hours after the desensitizing treatment (Figure 1).

Nevertheless, in each desensitizing treatment, there was a significant difference in the VAS score at different times compared to immediately after OB (Table 1) ($P<0.0001$).

Discussion

The present study was conducted with the aim of evaluating and comparing the effectiveness of potassium nitrate, sodium fluoride varnish, and diode Laser in reducing post bleaching sensitivity. Studies reported that tooth sensitivity

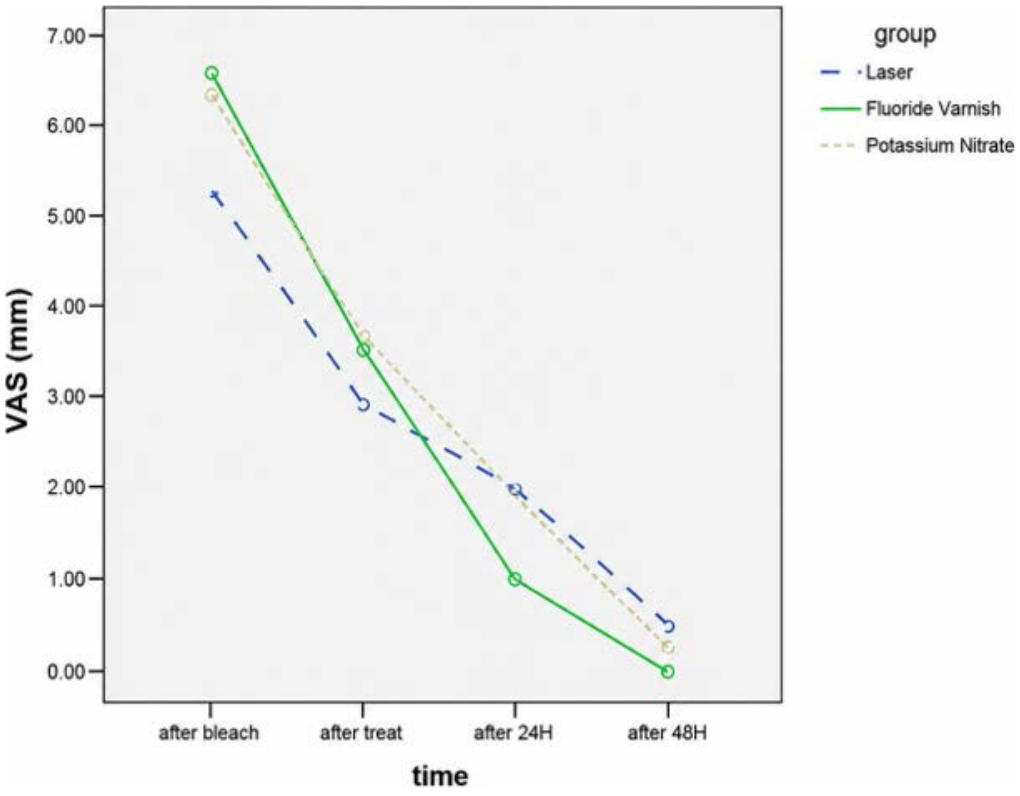


Figure 1. VAS scores at different times in the studied groups

Table 1. Mean ± SD of VAS scores at different times in the studied groups

Desensitizing method	Immediately after desensitizing treatment Mean ± SD (mm)	24 hrs. after desensitizing treatment Mean ± SD (mm)	48 hrs. after desensitizing treatment Mean ± SD (mm)
Diod Laser	$1.44 \pm 2.94_{a}$	$2.06 \pm 2.03_{b}$	$0.72 \pm 0.52_{c}$
Sodium fluoride	$1.44 \pm 3.53_{a}$	$1.23 \pm 1.04_{b}$	0_{c}
Potassium nitrate	$1.75 \pm 3.67_{a}$	$1.92 \pm 1.93_{b}$	$0.62 \pm 0.27_{c}$

Identical letters indicated no significant difference ($P > 0.05$)

affects 60 to 100% of patients who receive bleaching treatment, especially when office bleaching is the selected protocol.[7, 25, 26] Tooth sensitivity caused by bleaching is one of the most common side effects of bleaching and may have several causes; it cannot be completely prevented.[27] The active ingredient in bleaching materials contains peroxide; since hydrogen peroxide has a very low molecular weight, it can easily penetrate the enamel and dentin, reach the dental pulp in just a few minutes,[28] and stimulate pain receptors to transmit sensitivity.[18, 29] Generally, desensitizing agents act through two mechanisms: blocking the dentinal tubules or depolarizing the nerve. Dentin tubule blockage works through protein deposition or the formation of a surface layer, while nerve depolarization involves the penetration and diffusion of ions into the dentin structure that finally reach the pulp. In the current study, all desensitizing treatments caused a significant reduction in sensitivity compared to immediately after OB; thus, the first hypothesis of the study was rejected.

Potassium nitrate has been described as a good alternative to minimize this side effect. The results of the present study showed that post bleaching sensitivity significantly decreased following the use of potassium nitrate; this is consistent with the studies conducted by Martini,[30] Ortega,[31] Nanjundasetty,[17] and Pintado.[32] In the study by Nanjundasetty et al. (2016), in the potassium nitrate group, the incidence and severity of post bleaching sensitivity were significantly lower than placebo 10 minutes, 24 hours, and 7 days after the treatment.[17] In a study aiming at evaluating the effectiveness of potassium nitrate in reducing post-OB sensitivity, Ortega et al. showed that toothpaste containing 5% potassium nitrate significantly reduced tooth sensitivity immediately and 48 hours after bleaching compared to a placebo.[31] One study showed that 30 minutes after applying potassium nitrate to bleached teeth, it could be detected in the pulp [(?)]. It seems that by increasing the concentration of potassium ions around the nerve fibers, the stimulation and activity of sensory nerves in the dentin tubules and pulp tissue are reduced.[18]

Similar recent evidence supports these findings, with randomized trials in 2022 and 2023 also reporting a significant reduction in post-bleaching sensitivity using topical potassium nitrate formulations.[33-34]

Another protocol for reducing post bleaching sensitivity in the present study was the use of sodium fluoride varnish. The results indicated that post bleaching sensitivity decreased significantly and even reached zero after 24 hours. This finding was consistent with the studies by Gaffar (1999) and Kumar (2005).[33] In addition, in a research study, Leonard Jr. (2004) used 0.11% fluoride 30 minutes before OB to reduce post bleaching sensitivity and found that it reduces sensitivity.[34] In a study using a fluoride-containing bleaching agent, Chen et al. (2008) also showed a decrease in post bleaching sensitivity.[35] The decrease in post bleaching sensitivity by sodium fluoride varnish can be attributed to the formation of calcium, phosphorus and fluorapatite deposits that block the lingual movement inside the dentinal tubules, which in turn prevents the stimulation of interdental nerves, thereby decreasing sensitivity.[36]

Studies have reported the promising effect of laser therapy in the treatment of post bleaching sensitivity.[23, 37] In the present study, it was also found that Low-Level Laser Therapy (LLLT), such as the diode laser, leads to a significant decrease in post bleaching sensitivity; this is consistent with the study by Kumar and Mehta (2005). Another clinical study also revealed that LLLT can be used as a treatment to reduce post bleaching sensitivity after bleaching.[38] Regarding the reason for the effect of laser radiation, reference can be made to the ability of LLLT to stimulate photoreceptors, which can change the functional and metabolic activity of cells by absorbing specific wavelength photons,[39] leading to less pulp damage following bleaching.[40, 41] LLLT also induces tertiary dentin deposition as a biostimulant.[21, 42] In addition, LLLT has analgesic and anti-inflammatory effects.

In more recent clinical investigations, Al−Qarni et al. (2020) and Ahmed et al. (2023) confirm that diode laser therapy remains a viable and effective option for rapid sensitivity reduction immediately following bleaching.[40-43]

In the present research, there was no significant difference between the three desensitizing methods used in reducing post bleaching sensitivity; thus, the second hypothesis of the study was confirmed. Consistent with the present study, in the study by Ghidaa et al. (2021), sodium fluoride varnish and laser therapy reduced the level of tooth sensitivity; yet, there was no significant difference between them.[23] Also, Brennda et al. (2018) did not observe any significant difference between the diode laser and potassium nitrate, although, like the present study, both reduced sensitivity.[43] In the study by Kashi et al, potassium nitrate and sodium monofluorophosphate did not show any significant difference, and both were able to reduce post bleaching sensitivity.[17] It can be concluded that new methods, such as lasers, can replace older methods. Nevertheless, choosing the appropriate treatment method to reduce post bleaching sensitivity should be based on the available facilities and conditions.

All the investigated groups in the present study showed the highest level of sensitivity immediately after OB; this is in line with the studies conducted by Paula and Coppla.[44-13]

Moreover, in the present study, similar to the study conducted by Coppla (2018),[13] Paula (2013) and Rezende (2016),[45] the level of sensitivity was measured up to 48 hours after OB. In these studies, as in the present study, the mean sensitivity score was less than 0.5 mm on the VAS scale 48 hours after desensitizing treatment. However, since sensitivity did not decrease significantly in one of the study groups even 72 hours after OB in the study by Brennda et al. (2018), it is suggested that future studies assess sensitivity levels over longer follow-up periods.[46] In the present study, similar to the study by Monica et al. (2018), the VAS was used to evaluate tooth sensitivity.[47] Nevertheless, the VAS scale is based on subjective feeling, and it cannot accurately determine the intensity of the stimulus [48]; on the other hand, pain is an emotional experience that may not be directly proportional to the intensity of the stimulus and may lead to the inability to determine the effectiveness of a certain treatment.[48]

A limitation of this study was the restricted sample size due to the limited number of eligible patients available during the study period. In addition, only the subjective Visual Analogue Scale (VAS) was used for sensitivity assessment. Future research should include objective measurement methods (e.g., thermal or electric pulp testing) to complement subjective pain scales. Moreover, future investigations are encouraged to adopt longitudinal follow-up designs to evaluate the persistence of desensitizing effects beyond the 48-hour period assessed in the present study.

Conclusion

Diod Laser, potassium nitrate, and sodium fluoride varnish are effective in reducing post bleaching sensitivity. Furthermore, there is no statistically significant difference between these desensitizing treatments. Choosing an appropriate method can be based on the available facilities and conditions, as well as the dentist's diagnosis of the patient's condition.

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Authors' Contribution

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Competing Interests

None.

Ethical Approval

The study protocol was approved by the Ethics Committee of Shahid Sadoughi University of Medical Sciences (license number: IR.SSU.DENTISTRY.REC.1402.022 and registered at (identifier: IRCT20230729058962N).

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