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# Comparative evaluation of diode laser with 2% sodium fluoride and 5% potassium nitrate in the treatment of dentin hypersensitivity

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## Abstract

**INTRODUCTION.** Dentin hypersensitivity is a common clinical condition that may negatively affect oral function and quality of life. Several desensitizing approaches are available, but no universally accepted treatment protocol has been established.

**AIM.** This study aimed to compare the clinical effectiveness of 5% potassium nitrate toothpaste and diode laser combined with 2% sodium fluoride gel in reducing dentin hypersensitivity.

**MATERIALS AND METHODS.** This assessor-blinded randomized clinical trial included 170 hypersensitive teeth from 17 patients aged 20–33 years. The teeth were allocated equally into two groups: 85 teeth were treated with 5% potassium nitrate toothpaste applied professionally for 30 seconds, and 85 teeth were treated with 2% sodium fluoride gel followed by diode laser irradiation using a 650 nm diode laser at 25 mW in continuous mode for 60 seconds. Pain intensity was assessed using a 10-point Visual Analog Scale at baseline, immediately after treatment, and after 1 week, 2 weeks, 1 month, and 3 months.

**RESULTS.** Both treatment groups showed significant reductions in VAS scores over the three-month follow-up period. In the 5% potassium nitrate group, the mean VAS score decreased from  $6.20 \pm 1.80$  at baseline to  $1.54 \pm 2.21$  after 3 months, corresponding to a 75.2% reduction. In the diode laser plus 2% sodium fluoride group, the mean VAS score decreased from  $5.47 \pm 1.15$  to  $0.42 \pm 0.89$ , corresponding to a 92.3% reduction. The diode laser plus sodium fluoride group showed lower VAS scores at all post-treatment follow-up intervals. However, baseline VAS scores differed significantly between the groups and should be considered when interpreting the comparative findings.

**CONCLUSION.** Both 5% potassium nitrate toothpaste and diode laser combined with 2% sodium fluoride gel were effective in reducing dentin hypersensitivity. Diode laser combined with 2% sodium fluoride showed a greater and more sustained reduction in VAS scores over three months, although the baseline imbalance between groups warrants cautious interpretation. Further randomized clinical trials with larger samples and baseline-adjusted analyses are recommended.

**Keywords:** dentin sensitivity, dentin desensitizing agents, diode laser, sodium fluoride, potassium nitrate, visual analog scale

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## Сравнительная оценка диодного лазера в сочетании с 2% фторидом натрия и 5% нитратом калия при лечении гиперчувствительности дентина

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### Резюме

**ВВЕДЕНИЕ.** Гиперчувствительность дентина является распространенным клиническим состоянием, которое может отрицательно влиять на функцию полости рта и качество жизни пациентов. Несмотря на наличие различных десенсибилизирующих методов лечения, универсально принятого протокола терапии до настоящего времени не существует.

**ЦЕЛЬ.** Целью данного исследования было сравнить клиническую эффективность зубной пасты с 5% нитратом калия и диодного лазера в сочетании с 2% гелем фторида натрия в снижении гиперчувствительности дентина.

**МАТЕРИАЛЫ И МЕТОДЫ.** В данное рандомизированное клиническое исследование с ослепленной оценкой результатов были включены 170 зубов с гиперчувствительностью у 17 пациентов в возрасте от 20 до 33 лет. Зубы были поровну распределены на две группы: 85 зубов лечили зубной пастой с 5% нитратом калия, профессионально нанесенной на 30 секунд, а 85 зубов лечили 2% гелем фторида натрия с последующим облучением диодным лазером с длиной волны 650 нм, мощностью 25 мВт, в непрерывном режиме в течение 60 секунд. Интенсивность боли оценивали с использованием 10-балльной визуальной аналоговой шкалы на исходном уровне, сразу после лечения, а также через 1 неделю, 2 недели, 1 месяц и 3 месяца.

**РЕЗУЛЬТАТЫ.** В обеих группах лечения наблюдалось значительное снижение показателей визуальной аналоговой шкалы в течение трехмесячного периода наблюдения. В группе 5% нитрата калия средний показатель визуально-аналоговой шкалы (ВАШ) снизился с  $6,20 \pm 1,80$  на исходном уровне до  $1,54 \pm 2,21$  через 3 месяца, что соответствует снижению на 75,2%. В группе диодного лазера в сочетании с 2% фторидом натрия средний показатель ВАШ снизился с  $5,47 \pm 1,15$  до  $0,42 \pm 0,89$ , что соответствует снижению на 92,3%. Группа диодного лазера в сочетании с фторидом натрия показала более низкие значения ВАШ на всех этапах наблюдения после лечения. Однако исходные показатели ВАШ статистически значимо различались между группами, что следует учитывать при интерпретации сравнительных результатов.

**ЗАКЛЮЧЕНИЕ.** Как зубная паста с 5% нитратом калия, так и диодный лазер в сочетании с 2% гелем фторида натрия были эффективны в снижении гиперчувствительности дентина. Диодный лазер в сочетании с 2% фторидом натрия продемонстрировал более выраженное и устойчивое снижение показателей ВАШ в течение трех месяцев, однако исходный дисбаланс между группами требует осторожной интерпретации результатов. Рекомендуется проведение дальнейших рандомизированных клинических исследований с большей выборкой и анализом, скорректированным с учетом исходных различий.

**Ключевые слова:** гиперчувствительность дентина, десенсибилизирующие средства для дентина, диодный лазер, фторид натрия, нитрат калия, визуальная аналоговая шкала

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### INTRODUCTION

Dentin hypersensitivity is a common clinical condition characterized by short, sharp pain arising from exposed dentin in response to thermal, evaporative, tactile, osmotic, or chemical stimuli, which cannot be attributed to any other dental defect or pathological condition [1; 2]. Although it is often perceived as a minor complaint, dentin hypersensitivity may interfere with routine oral functions such as toothbrushing, drinking, eating, and receiving professional dental care, there-

by negatively affecting oral-health-related quality of life [1; 3]. Clinically, the condition remains challenging because its symptoms may overlap with other causes of dental pain, including caries, cracked tooth syndrome, defective restorations, reversible pulpitis, post-operative sensitivity, and periodontal-related root exposure. Therefore, accurate diagnosis requires careful patient history, clinical examination, exclusion of alternative causes, and standardized stimulus-based assessment [1; 4].

The hydrodynamic theory remains the most widely accepted explanation for dentin hypersensitivity. According to this theory, external stimuli induce fluid movement within exposed and patent dentinal tubules, activating pulpal mechanoreceptors and intra-dental nerve fibers, which results in acute pain [2; 4]. Accordingly, most therapeutic approaches are directed toward either reducing dentinal fluid movement by occluding open tubules or modifying neural transmission to reduce pain perception [1; 5]. The ideal desensitizing therapy should be easy to apply, non-irritating to the pulp, clinically safe, rapidly effective, durable, and acceptable to both clinicians and patients [5]. However, despite the wide range of available desensitizing agents and technologies, no universally accepted protocol has been established for the management of dentin hypersensitivity, and treatment outcomes remain variable across patients and clinical settings [1; 5].

Potassium nitrate is one of the most frequently used neural desensitizing agents for dentin hypersensitivity. Its proposed mechanism involves increasing extracellular potassium ion concentration around intra-dental nerve fibers, thereby reducing nerve excitability and limiting the propagation of pain signals [6; 7]. Several clinical studies have shown that potassium nitrate-containing toothpastes and mouthrinses can reduce dentin hypersensitivity when used regularly over time [7; 8]. Sharma et al. reported that potassium nitrate, whether used as toothpaste or mouthrinse, was effective in reducing symptoms of dentinal hypersensitivity [7]. Similarly, Hall et al. demonstrated that a 3% potassium nitrate mouthrinse provided significant relief when used adjunctively to toothbrushing over an eight-week period [8]. Nevertheless, potassium nitrate-based treatment usually depends on repeated application, patient compliance, and sufficient contact time to allow diffusion of potassium ions through dentinal tubules. These limitations create a rationale for investigating professional in-office application protocols that may provide faster and more controlled pain reduction.

Fluoride-based agents represent another major category of dentin hypersensitivity treatment. Sodium fluoride can reduce dentin permeability through the precipitation of calcium fluoride-like deposits on exposed dentin surfaces, contributing to partial occlusion of dentinal tubules and reduction of fluid movement [5; 9]. Qeli et al. reported that fluoride-based agents can significantly reduce hypersensitivity in patients with non-carious cervical lesions [9]. However, the clinical effect of fluoride alone may be transient because the deposited layer can be affected by saliva, dietary acids, and mechanical removal during toothbrushing [10]. Dantas et al. found that both fluoride varnish and low-level laser therapy reduced cervical dentin hypersensitivity, although short-term differences may depend on the treatment protocol and follow-up duration [10]. These findings suggest that fluoride is clinically useful but may benefit from adjunctive approaches that improve the stability of tubular occlusion.

Laser therapy has gained increasing attention as a non-invasive modality for dentin hypersensitivity management. Diode lasers are particularly relevant because of their clinical accessibility, compact design, and ability to operate across different wavelengths and power settings [11; 12]. The therapeutic effect of diode lasers depends on parameters such as wavelength, power output, exposure time, energy density, emission mode, and distance from the dentin surface. Low-level diode laser therapy may reduce pain through photobiomodulation, modulation of nerve conduction, anti-inflammatory effects, and stimulation of reparative dentin formation [11; 12]. In contrast, higher-energy laser settings may promote dentinal surface modification and narrowing or occlusion of dentinal tubules [12]. Yilmaz et al. showed that diode laser irradiation could provide a long-term desensitizing effect compared with sodium fluoride varnish in periodontal maintenance patients [11]. Pantuzzo et al. also reported that diode laser therapy was effective in reducing dentin hypersensitivity when compared with fluoride therapy [12].

Several clinical investigations have evaluated the combined use of diode laser therapy with fluoride-based desensitizing agents. Suri et al. reported that the combined application of diode laser and 5% sodium fluoride varnish produced greater reduction in dentin hypersensitivity than either modality used alone [13]. Jain et al. similarly found that diode laser therapy, alone or in combination with fluoride varnish, was more effective than fluoride varnish alone over a six-month period [14]. Femiano et al. further demonstrated that sodium fluoride used in association with diode laser irradiation improved pain reduction compared with sodium fluoride alone, supporting the concept that the laser may enhance the clinical stability and effectiveness of fluoride-based tubule occlusion [15]. More recently, Mohammadian et al. concluded in a systematic review of randomized clinical trials that diode laser therapy, particularly when combined with sodium fluoride varnish, represents a promising treatment approach for dentin hypersensitivity and may provide superior efficacy compared with fluoride varnish alone [16].

The wavelength used in diode laser therapy is also clinically important. Jomaa et al. compared 810 nm and 650 nm diode lasers, used alone and in combination with sodium fluoride gel, and reported that both wavelengths reduced dentin hypersensitivity, although treatment response varied according to wavelength and combined application protocol [17]. This is directly relevant because many clinical protocols differ in laser parameters, fluoride concentration, application time, and follow-up duration. As a result, the literature remains heterogeneous, and additional controlled clinical comparisons are still needed to define practical treatment protocols.

Despite the growing evidence supporting potassium nitrate, sodium fluoride, diode laser therapy, and combined laser-fluoride protocols, the available literature remains heterogeneous in terms of laser wave-

length, power settings, fluoride concentration, application time, treatment frequency, and follow-up duration. More importantly, limited clinical evidence has directly compared a single professional application of 5% potassium nitrate with a combined protocol using 2% sodium fluoride and a 650 nm diode laser under the same clinical conditions. Such a comparison is clinically relevant because potassium nitrate represents a widely available, low-cost desensitizing option, whereas diode laser combined with sodium fluoride may offer a more advanced in-office treatment with faster and more durable pain reduction. Therefore, this study aimed to clinically evaluate and compare the effectiveness of 5% potassium nitrate and diode laser combined with 2% sodium fluoride in reducing dentin hypersensitivity over a three-month follow-up period.

## MATERIALS AND METHODS

### Study Design and Setting

This study was designed as an assessor-blinded randomized clinical trial with tooth-level allocation to compare two in-office treatment modalities for dentin hypersensitivity. The study was conducted at the Department of Restorative and Esthetic Dentistry, Faculty of Dentistry, Sana'a University, and at Dr. Seham Al-Ghursi Center, Sana'a, Yemen.

### Study Population

The study population consisted of patients attending the outpatient dental clinics who required treatment for dentin hypersensitivity. A total of 17 patients, including 12 males and 5 females, aged between 20 and 33 years, were enrolled in the study. Overall, 170 hypersensitive teeth were included and allocated equally into two treatment groups, with 85 teeth in each group.

### Sample Size

The sample size was calculated using G\*Power software. The calculation was based on a medium effect size of 0.5, a study power of 80%, and an alpha error of 0.05. The minimum required sample size was estimated to be 168 teeth; therefore, 170 hypersensitive teeth were included in the final analysis.

### Eligibility Criteria

Participants were selected according to predefined clinical inclusion and exclusion criteria.

#### *Inclusion Criteria*

Patients were included if they had one or more teeth diagnosed with dentin hypersensitivity, were in good general health, had hypersensitive teeth free from caries or extensive restorations, and agreed to participate by signing informed consent.

#### *Exclusion Criteria*

Patients were excluded if they had a previous history of treatment for dentin hypersensitivity, poor periodontal condition, systemic debilitating disease, caries or restoration in the area of hypersensitivity, allergy to any material used in the study, or orthodontic appliances, crowns, or bridges in the sensitive area.

### Randomization and Blinding

The 170 hypersensitive teeth were randomly allocated into two equal groups. Group 1 included 85 teeth treated with diode laser combined with 2% sodium fluoride, while Group 2 included 85 teeth treated with 5% potassium nitrate toothpaste.

The treatment procedures were performed by one experienced operator. Outcome assessment was performed by an examiner who was independent from the operator and blinded to the treatment allocation. Because the use of laser therapy could not be fully concealed from the operator, the study is described as assessor-blinded rather than fully double-blinded.

### Materials

The materials used in this study included sterile gloves, masks, protective eyewear, cotton rolls for isolation, 2% sodium fluoride gel (Frutti Fluor Gel Neutro, Biodinâmica, Brazil), a dental diode laser device (Woodpecker LX16 Plus), and 5% potassium nitrate toothpaste (Sensi Kin, Laboratories KIN S.A., Spain).

The clinical materials and application procedures are shown in Figure 1.

### Pre-treatment Assessment

Before treatment, each hypersensitive tooth was isolated using cotton rolls. Dentin hypersensitivity was assessed using the air-blast method. Compressed air was delivered from a three-way syringe for one second at a distance of approximately 10 mm from the tooth surface. The patient was then asked to report the perceived pain intensity using a 10-point Visual Analog Scale (VAS), where 0 indicated no pain and 10 indicated maximum pain. Teeth with a baseline VAS score below 4 were excluded from the study.

### Intervention Protocols

#### *Group 1: Diode Laser Combined with 2% Sodium Fluoride*

In the diode laser and sodium fluoride group, a thin layer of 2% sodium fluoride gel was applied to the hypersensitive tooth surface using a micro-brush for 30 seconds. Immediately after sodium fluoride application, the treated tooth surface was irradiated using a 650 nm diode laser with an output power of 25 mW in continuous emission mode. The laser was applied in non-contact mode, with the beam directed perpendicular to the buccal surface of each treated tooth for 60 seconds.

After treatment, patients were instructed not to eat for one hour and to resume tooth cleaning after 12 hours.

#### *Group 2: 5% Potassium Nitrate Toothpaste*

In the potassium nitrate group, hypersensitive teeth were treated with a desensitizing toothpaste containing 5% potassium nitrate. The toothpaste was professionally applied to the sensitive area using a micro-brush for 30 seconds.

### Outcome Assessment

The primary outcome was the change in dentin hypersensitivity pain score, measured by VAS, from baseline to three months after treatment. Secondary out-

comes included changes in VAS scores immediately after treatment, after one week, after two weeks, and after one month.

At each follow-up interval, dentin hypersensitivity was reassessed using the same standardized air-blast method, and patients reported their pain score using the VAS.

### Statistical Analysis

Data were analyzed using SPSS software, version 23.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to summarize demographic and clinical data. Continuous variables were presented as mean and standard deviation, while categorical variables were presented as frequencies and percentages.

The Mann–Whitney U test was used to compare VAS scores between the two treatment groups at each time interval. The Wilcoxon signed-rank test was used to compare changes in VAS scores within each group across follow-up intervals. Statistical significance was set at  $p \leq 0.05$ .

Because multiple teeth were included from the same patients, the tooth was considered the unit of analysis. This tooth-level allocation is reported transparently, and the possible clustering effect of teeth within individual patients should be considered when interpreting the findings.

### Ethical Considerations

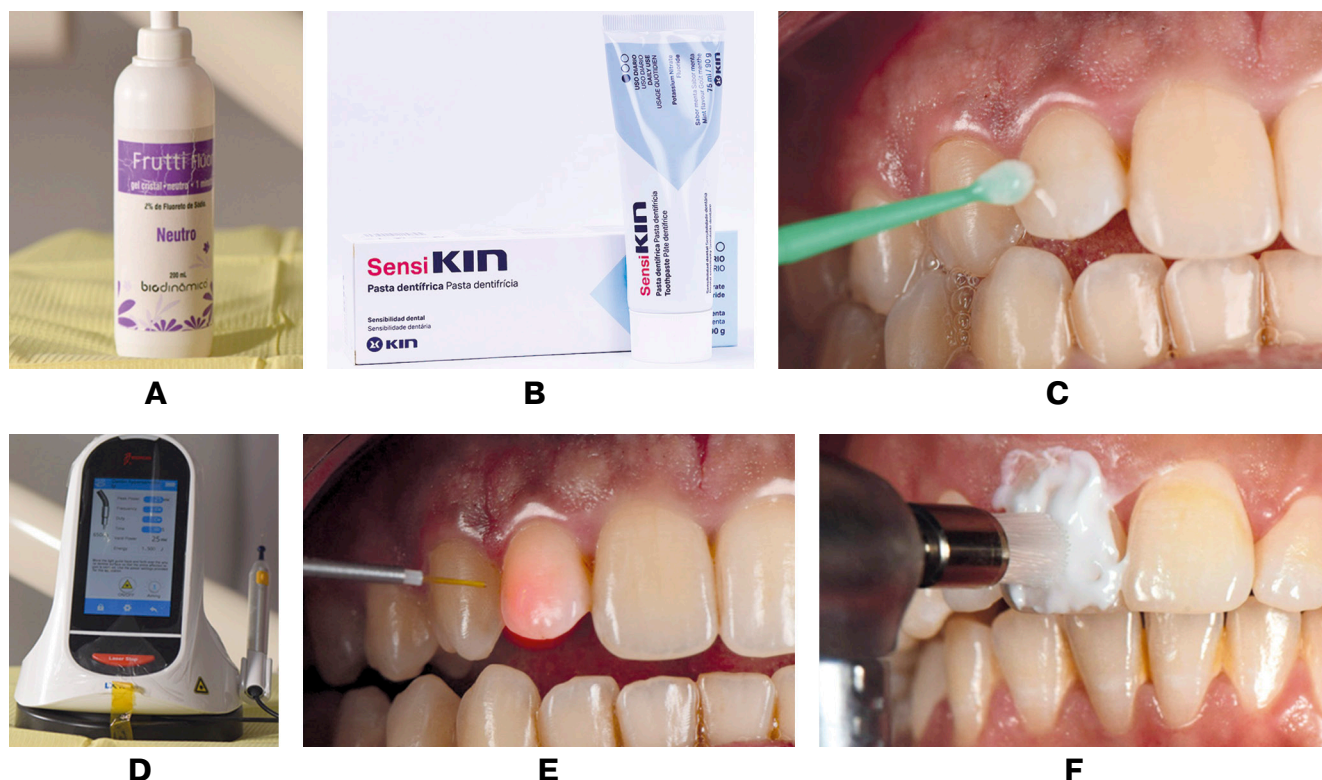
The study protocol was approved by the Medical Ethics Committee of the Faculty of Dentistry, Sana'a University, Yemen (Approval No. FP:09/10/2024). Written informed consent was obtained from all participants before enrollment. Patient confidentiality was maintained throughout the study, and all procedures were conducted in accordance with the ethical principles for clinical research involving human participants.

## RESULTS

### Study Sample and Baseline Characteristics

A total of 17 patients with dentin hypersensitivity were included in the study. The sample consisted of 12 males (70.6%) and 5 females (29.4%). The mean age of the participants was  $25.8 \pm 3.91$  years, with an age range of 20 to 33 years. Overall, 170 hypersensitive teeth were evaluated and allocated equally into two treatment groups: 85 teeth were treated with 5% potassium nitrate toothpaste, and 85 teeth were treated with diode laser combined with 2% sodium fluoride.

The distribution of treated teeth was relatively balanced between the upper and lower arches, with 87 teeth (51.2%) in the upper arch and 83 teeth (48.8%) in the lower arch. The treated teeth were also distributed across both sides of the jaw, with 81 teeth (47.6%) on the right side and 89 teeth (52.4%) on the left side.



**Fig. 1.** Clinical materials and application procedures used in the study: A – Sodium fluoride (Frutti Fluor Gel Neutro); B – Potassium nitrate toothpaste (Sensi Kin); C – Sodium fluoride gel application; D – Protocol setting of Woodpecker LX16 Plus diode laser; E – Diode laser application; F – Potassium nitrate toothpaste application with micro brush

**Рис. 1.** Клинические материалы и процедуры, которые применялись в исследовании: А – фторид натрия (Frutti Fluor Gel Neutro); В – зубная паста с нитратом калия (Sensi Kin); С – нанесение геля с фторидом натрия; D – настройка протокола диодного лазера Woodpecker LX16 Plus; E – применение диодного лазера; F – нанесение зубной пасты с нитратом калия микрощеточкой

### Between-Group Comparison of VAS Scores

At baseline, the mean VAS score was  $6.20 \pm 1.80$  in the 5% potassium nitrate group and  $5.47 \pm 1.15$  in the diode laser plus 2% sodium fluoride group. The baseline difference between the two groups was statistically significant ( $p = 0.018$ ), indicating that initial pain intensity was higher in the potassium nitrate group.

Both treatment groups showed a progressive reduction in VAS scores after treatment. However, the diode laser plus 2% sodium fluoride group demonstrated lower mean VAS scores than the potassium nitrate group at all post-treatment follow-up intervals. Immediately after treatment, the mean VAS score decreased to  $3.62 \pm 1.41$  in the potassium nitrate group and to  $3.08 \pm 1.19$  in the diode laser plus sodium fluoride group ( $p = 0.025$ ). After one week, the VAS scores were  $2.49 \pm 1.18$  and  $2.05 \pm 1.01$ , respectively ( $p = 0.011$ ). After two weeks, the diode laser plus sodium fluoride group continued to show a lower VAS score, with a mean value of  $1.56 \pm 1.11$  compared with  $2.27 \pm 1.43$  in the potassium nitrate group ( $p = 0.002$ ).

This pattern was maintained at the later follow-up intervals. After one month, the mean VAS score was  $2.31 \pm 2.08$  in the potassium nitrate group and  $1.18 \pm 1.16$  in the diode laser plus sodium fluoride group ( $p = 0.001$ ). At three months, the diode laser plus sodium fluoride group showed the lowest pain score, reaching  $0.42 \pm 0.89$  compared with  $1.54 \pm 2.21$  in the potassium nitrate group ( $p = 0.001$ ).

These findings indicate that both treatments reduced dentin hypersensitivity, while diode laser combined with 2% sodium fluoride showed lower VAS scores throughout the three-month follow-up period.

**Table 1.** Baseline demographic and clinical characteristics of the study sample

**Таблица 1.** Исходные демографические и клинические характеристики исследуемой выборки

| Variable        | Category                         | n           | %    |
|-----------------|----------------------------------|-------------|------|
| Sex             | Male                             | 12          | 70.6 |
|                 | Female                           | 5           | 29.4 |
| Age group       | ≤ 25 years                       | 8           | 47.1 |
|                 | > 25 years                       | 9           | 52.9 |
| Age             | Mean ± SD                        | 25.8 ± 3.91 | –    |
| Age range       | Years                            | 20–33       | –    |
| Treatment group | 5% potassium nitrate             | 85 teeth    | 50.0 |
|                 | Diode laser + 2% sodium fluoride | 85 teeth    | 50.0 |
| Dental arch     | Upper                            | 87 teeth    | 51.2 |
|                 | Lower                            | 83 teeth    | 48.8 |
| Jaw side        | Right                            | 81 teeth    | 47.6 |
|                 | Left                             | 89 teeth    | 52.4 |

However, because baseline VAS scores differed significantly between the two groups, the between-group differences should be interpreted with consideration of the initial imbalance in pain intensity. Therefore, both absolute VAS scores and percentage reductions from baseline were reported to provide a more balanced interpretation of treatment response.

### Within-Group Changes Over Time

Within-group analysis showed that 5% potassium nitrate toothpaste significantly reduced dentin hypersensitivity at all follow-up intervals compared with baseline. The VAS score decreased from  $6.20 \pm 1.80$  at baseline to  $3.62 \pm 1.41$  immediately after treatment, representing a 41.6% reduction. The reduction increased to 59.8% after one week, 63.4% after two weeks, 62.7% after one month, and 75.2% after three months. All within-group comparisons were statistically significant ( $p < 0.001$ ).

The diode laser plus 2% sodium fluoride group also showed a significant and progressive reduction in VAS scores across all follow-up intervals. The mean VAS score decreased from  $5.47 \pm 1.15$  at baseline to  $3.08 \pm 1.19$  immediately after treatment, corresponding to a 43.7% reduction. Pain reduction continued over time, reaching 62.5% after one week, 71.5% after two weeks, 78.4% after one month, and 92.3% after three months. All within-group comparisons were statistically significant ( $p < 0.001$ ).

Overall, both treatments produced clinically meaningful improvement in dentin hypersensitivity. However, the magnitude of pain reduction was greater in the diode laser plus 2% sodium fluoride group, particularly at the three-month follow-up.

**Table 2.** Comparison of visual analogue scale scores between the two treatment groups over time

**Таблица 2.** Сравнение показателей визуально-аналоговой шкалы между двумя группами лечения с течением времени

| Time interval               | 5% potassium nitrate Mean ± SD | Diode laser + 2% sodium fluoride Mean ± SD | p-value |
|-----------------------------|--------------------------------|--------------------------------------------|---------|
| Baseline                    | 6.20 ± 1.80                    | 5.47 ± 1.15                                | 0.018   |
| Immediately after treatment | 3.62 ± 1.41                    | 3.08 ± 1.19                                | 0.025   |
| After 1 week                | 2.49 ± 1.18                    | 2.05 ± 1.01                                | 0.011   |
| After 2 weeks               | 2.27 ± 1.43                    | 1.56 ± 1.11                                | 0.002   |
| After 1 month               | 2.31 ± 2.08                    | 1.18 ± 1.16                                | 0.001   |
| After 3 months              | 1.54 ± 2.21                    | 0.42 ± 0.89                                | 0.001   |

*Note.* p-values were calculated using the Mann–Whitney U test. VAS: Visual Analog Scale; SD: standard deviation.

*Примечание.* p-значения были рассчитаны с использованием U-критерия Манна-Уитни. ВАШ – визуальная аналоговая шкала; SD – стандартное отклонение.

**Table 3.** Percentage reduction in visual analogue scale scores from baseline within each treatment group

**Таблица 3.** Процентное снижение показателей визуально-аналоговой шкалы по сравнению с исходным уровнем в каждой группе лечения

| Follow-up interval          | 5% potassium nitrate reduction, % | Diode laser + 2% sodium fluoride reduction, % |
|-----------------------------|-----------------------------------|-----------------------------------------------|
| Immediately after treatment | 41.6                              | 43.7                                          |
| After 1 week                | 59.8                              | 62.5                                          |
| After 2 weeks               | 63.4                              | 71.5                                          |
| After 1 month               | 62.7                              | 78.4                                          |
| After 3 months              | 75.2                              | 92.3                                          |

*Note.* Percentage reductions were calculated from the mean VAS scores reported in Table 2. All within-group changes from baseline were statistically significant ( $p < 0.001$ ), based on the Wilcoxon signed-rank test.

*Примечание.* Процентное снижение было рассчитано на основе средних показателей визуально-аналоговой шкалы, представленных в табл. 2. Все внутригрупповые изменения по сравнению с исходным уровнем были статистически значимыми ( $p < 0.001$ ), основываясь на знаково-ранговом тесте Уилкоксона.

### Exploratory Subgroup Findings

Exploratory subgroup analyses showed that the response to 5% potassium nitrate was not significantly affected by age group, dental arch, or jaw side at any follow-up interval. Similarly, treatment response in the diode laser plus 2% sodium fluoride group was not significantly influenced by dental arch or jaw side.

However, age-related differences were observed in the diode laser plus sodium fluoride group at two weeks and one month. Patients aged  $\leq 25$  years showed lower VAS scores than those aged  $> 25$  years at the two-week and one-month follow-up intervals. This finding should be interpreted cautiously because the subgroup analysis was exploratory and based on a limited number of patients.

### DISCUSSION

Dentin hypersensitivity remains a clinically challenging condition because pain perception is subjective and treatment response may vary according to patient-related, tooth-related, and procedure-related factors. The present study compared two in-office treatment protocols for dentin hypersensitivity: a single professional application of 5% potassium nitrate toothpaste and a combined protocol using 2% sodium fluoride with a 650 nm diode laser. The main finding was that both treatment modalities significantly reduced dentin hypersensitivity over the three-month follow-up period. However, the diode laser combined with 2% sodium fluoride showed lower VAS scores at all post-treatment follow-up intervals and produced a greater percentage reduction in pain by the end of the study.

In the 5% potassium nitrate group, the mean VAS score decreased from  $6.20 \pm 1.80$  at baseline to  $1.54 \pm 2.21$  after three months, corresponding to a 75.2% reduction from baseline. This finding indicates that a single professional application of potassium nitrate can provide clinically meaningful improvement

in dentin hypersensitivity. The effect of potassium nitrate is commonly explained by its neural desensitizing mechanism. Potassium ions are believed to increase the extracellular potassium concentration around intradental nerve fibers, reduce nerve excitability, inhibit repolarization, and consequently decrease the transmission of pain impulses. This mechanism differs from tubule-occluding agents, as potassium nitrate primarily acts on neural response rather than physically sealing dentinal tubules.

The improvement observed in the potassium nitrate group is consistent with previous clinical evidence supporting the use of potassium nitrate-containing desensitizing agents for dentin hypersensitivity. Previous studies have reported that potassium nitrate toothpastes and mouthrinses can reduce sensitivity when used regularly over time. The present findings suggest that professional in-office application may also produce a measurable short-term and medium-term reduction in pain. Nevertheless, the clinical effect of potassium nitrate may depend on sufficient diffusion through dentinal tubules and may be influenced by contact time, application protocol, and patient-related factors. Therefore, while potassium nitrate remains a practical, low-cost, and accessible desensitizing option, its effect may be less pronounced than combined approaches that target both neural response and dentinal tubule occlusion.

The diode laser combined with 2% sodium fluoride produced a stronger reduction in dentin hypersensitivity. In this group, the mean VAS score decreased from  $5.47 \pm 1.15$  at baseline to  $0.42 \pm 0.89$  after three months, representing a 92.3% reduction from baseline. This greater reduction may be explained by the complementary mechanisms of sodium fluoride and diode laser therapy. Sodium fluoride contributes to dentinal tubule occlusion through the formation of calcium fluoride-like deposits on exposed dentin surfaces, thereby reducing dentinal fluid movement.

Meanwhile, low-level diode laser irradiation may contribute to pain reduction through photobiomodulation, modulation of nerve conduction, anti-inflammatory effects, and possible stimulation of reparative dentin formation.

The combined effect of diode laser and sodium fluoride may therefore provide a dual mechanism: chemical occlusion of dentinal tubules by fluoride-derived deposits and biological modulation of pain response by laser irradiation. This may explain the more sustained decrease in VAS scores observed in the laser-fluoride group throughout the follow-up period. Previous studies have similarly reported that diode laser therapy can reduce dentin hypersensitivity and that combining laser irradiation with fluoride-based agents may improve clinical outcomes compared with either treatment alone [13–16]. Previous studies have similarly reported that diode laser therapy can reduce dentin hypersensitivity and that combining laser irradiation with fluoride-based agents may improve clinical outcomes compared with either treatment alone. Suri et al. reported that the combined application of diode laser and sodium fluoride varnish produced greater improvement than single-modality treatment [13]. Jain et al. also found that diode laser combined with fluoride varnish was effective in reducing dentin hypersensitivity over time [14]. More recently, systematic evidence has supported the potential benefit of combined laser-fluoride protocols, although treatment parameters remain heterogeneous across studies.

The findings of the present study are also consistent with clinical studies evaluating diode laser therapy at different wavelengths. Diode lasers have been reported to reduce dentin hypersensitivity through mechanisms that vary according to wavelength, output power, irradiation time, and application mode. In the present study, a 650 nm diode laser was used with low output power and continuous mode, suggesting that the observed effect was more likely related to photobiomodulation and neural modulation than to aggressive dentinal melting. This is clinically relevant because low-level laser protocols may offer pain reduction while minimizing the risk of thermal injury to the pulp when applied under controlled parameters.

Although the diode laser combined with 2% sodium fluoride showed lower VAS scores at all post-treatment follow-up intervals, interpretation of this finding should consider the statistically significant baseline difference between the two groups. The potassium nitrate group had a higher initial VAS score than the laser-fluoride group, which may have influenced the magnitude of absolute post-treatment differences. For this reason, the results were interpreted using both follow-up VAS scores and percentage reductions from baseline. Under this interpretation, both treatments produced clinically meaningful improvement, while the diode laser combined with 2% sodium fluoride demonstrated the greater percentage reduction by the end of the three-month follow-up period.

The exploratory subgroup findings showed that dental arch and jaw side did not appear to substantially

influence treatment response in either group. This suggests that both protocols may be applicable across different tooth locations, although these findings should not be overinterpreted due to the limited number of patients. Age-related differences were observed in the diode laser plus sodium fluoride group at two weeks and one month, where younger patients showed lower VAS scores than older patients. This may reflect differences in dentinal tubule patency, dentin sclerosis, or biological response to laser therapy. However, because this was an exploratory analysis based on a small sample, further studies with larger patient populations are required before drawing firm conclusions regarding age-related treatment response.

The clinical implication of this study is that both 5% potassium nitrate and diode laser combined with 2% sodium fluoride can reduce dentin hypersensitivity after professional application. Potassium nitrate may be useful as a simple, affordable, and accessible option, particularly in settings where laser devices are not available. However, the diode laser and sodium fluoride combination may be preferable when a more pronounced and sustained reduction in sensitivity is desired, provided that the clinician has appropriate laser training and follows safe irradiation parameters.

This study has several limitations. First, the number of patients was relatively small, although the number of treated teeth was larger. Second, multiple teeth were included from the same patients, which may introduce clustering effects because teeth within the same individual are not fully independent. Third, the baseline VAS scores differed significantly between the two treatment groups, and no baseline-adjusted statistical model was performed. Therefore, the comparative advantage of diode laser combined with 2% sodium fluoride should be interpreted cautiously. Fourth, the follow-up period was limited to three months, so longer-term durability of the treatment effects remains uncertain. Future studies should include larger samples, patient-level or split-mouth randomization with clear allocation concealment, sham-laser control where feasible, longer follow-up periods, and baseline-adjusted statistical analyses such as ANCOVA, generalized estimating equations, or mixed-effects models.

Overall, the results suggest that both treatment protocols are effective in reducing dentin hypersensitivity. However, diode laser combined with 2% sodium fluoride showed a greater and more sustained reduction in VAS scores over three months, supporting its potential role as an effective in-office treatment option for dentin hypersensitivity.

## CONCLUSION

Both 5% potassium nitrate toothpaste and diode laser combined with 2% sodium fluoride were effective in reducing dentin hypersensitivity over the three-month follow-up period. The diode laser plus 2% sodium fluoride group showed lower VAS scores and a greater percentage reduction in pain compared with the 5% potassium nitrate group, suggesting a more pronounced and sustained clinical effect.

However, because baseline VAS scores differed significantly between the two groups and baseline-adjusted analysis was not performed, the comparative findings should be interpreted cautiously. Within these limitations, diode laser combined with 2% sodium fluoride may be considered a promising in-office

treatment option for dentin hypersensitivity. Further randomized clinical trials with larger patient samples, longer follow-up periods, clear allocation procedures, and baseline-adjusted statistical analyses are recommended to confirm these findings.

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