

# Comparative Evaluation of 1.23 % Sodium Fluoride (NaF) gel Iontophoresis and Laser Assisted Desensitizing Techniques for Treating Dentinal Hypersensitivity: A Clinical Study

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## Abstract

**Background and Aim:** Management of Dentinal hypersensitivity (DH) includes at-home agents such as desensitizing toothpaste and mouthrinses containing potassium nitrate or fluorides, and in-office procedures such as iontophoresis, which enhances fluoride penetration, and diode laser therapy, which seals dentinal tubules and stimulates secondary dentin formation. The present clinical trial aimed to compare the effectiveness of 1.23% NaF gel iontophoresis and diode laser therapy in managing dentinal hypersensitivity.

**Material and Method:** Twenty-eight patients with clinically diagnosed dentinal hypersensitivity were allocated into two groups. Group I received diode laser therapy (980 nm, 0.5 W, non-contact, 1 min per tooth; n=14), and Group II received 1.23% NaF gel iontophoresis (n=14). Sensitivity was evaluated using an air-blast test and patient-reported Visual Analogue Scale (VAS) and Verbal Rating Scale (VRS) scores at baseline, 1 week, and 2 weeks. Data were analyzed using paired and independent t-tests with  $p < 0.05$  considered statistically significant.

**Results:** Group I (diode laser) showed no immediate change in VAS and VRS scores but demonstrated significant reductions at 1 week and 2 weeks ( $p < 0.001$ ). Group II (NaF iontophoresis) showed significant immediate reduction ( $p < 0.001$ ) with further improvement at

1 and 2 weeks ( $p < 0.001$ ). Inter-group comparison revealed greater immediate reduction in Group II but significantly lower scores in Group I at 2 weeks (VAS  $p = 0.035$ ; VRS  $p = 0.015$ )

**Conclusion:** The research results showed that both diode laser therapy and iontophoresis were effective in reducing dentinal hypersensitivity. However, diode laser demonstrated superior long-term efficacy, indicating its potential as a reliable standalone treatment for achieving sustained relief.

**Key Words:** Dentinal hypersensitivity, Diode laser, Iontophoresis, Sodium fluoride, VAS score.

## Introduction:

Dentin hypersensitivity (DH) is a common clinical condition characterized by brief, sharp pain arising from exposed dentin in response to non-noxious stimuli such as thermal, evaporative, tactile, osmotic, or chemical triggers, which cannot be attributed to any other dental condition [1,2]. This pain can occur intermittently and affect the quality of life of patients. It affects approximately 8% to 57% of adults and is observed more frequently in patients with periodontitis (60–98%). It is more common in females and typically occurs in individuals aged 30–40 years. The condition can involve any tooth, with the cervical buccal aspect of canines and premolars being most commonly affected [3,4]. DH develops when dentin tubules become exposed due to enamel or cementum loss caused by gingival recession, abrasion, attrition, abfraction, erosion, improper brushing techniques, or following periodontal therapy [4,5].

Management of DH is generally stepwise, starting with at-home treatments and progressing to in-office interventions if necessary. At-home strategies include the use of desensitizing toothpastes and mouth rinses containing potassium nitrate, fluoride, strontium salts, or arginine, which occlude dentinal tubules or modulate nerve excitability [6,7]. In-office procedures include topical fluoride applications, adhesive agents, and bioactive restorative materials such as bioactive glass and glass ionomer cement, which occlude tubules and provide sustained fluoride release [8,9]. Iontophoresis employs a low-intensity direct current to enhance penetration of ions such as fluoride into dentin. Sodium fluoride (1.23% NaF) dissociates into  $\text{Na}^+$  and  $\text{F}^-$  ions, which are driven into the dentinal tubules by the electric field, where fluoride reacts with calcium ions to form calcium fluoride ( $\text{CaF}_2$ ). This occludes tubules, reduces fluid movement, and alleviates sensitivity [10,11].

Laser therapy can reduce DH either by modulating nerve responses or occluding dentinal tubules. Low-level diode lasers (810–980 nm) promote tertiary dentin formation through photobiomodulation, whereas high-power lasers such as Nd:YAG (1064 nm) and Er:YAG (2940 nm) produce thermal effects that melt peritubular dentin and create a glazed surface [12,13]. Combining lasers with desensitizing agents may enhance efficacy, and refractory cases may require restorative or periodontal interventions [14]. The present study aims to compare the efficacy of 1.23% sodium fluoride gel application, iontophoresis, and diode laser therapy in the management of dentinal hypersensitivity, thereby identifying the most effective clinical modality for improving patient outcomes.

## **Materials and Methods:**

### **Study design and ethical considerations:**

A single blind randomized clinical trial was conducted in the Department of Periodontics, GITAM Dental College and Hospital, Visakhapatnam. A total of 28 patients aged between 18 years and 45 years with hypersensitive teeth were included in this study. Twenty-eight patients aged 18–45 years with dentinal hypersensitivity were included. The study adhered to the Declaration of Helsinki (2013) and was approved by the Institutional Ethical Committee [IEC Protocol Number: 78086061423] [15].

### **Sample size, randomization, and blinding:**

The sample size for this study was determined using the G\*Power software based on data from a pilot study, with an alpha level of 0.05, an effect size (d) calculated from pilot results, and a power level of 0.8. The analysis indicated that a minimum of 14 teeth per group was required. Randomisation was performed by an independent dental student using a table of random numbers. Each tooth was assigned a coded slip, unknown to the participant, and allocated to one of the two study groups: Group I (Diode Laser) or Group II (NaF Iontophoresis). This was a single-blind trial in which participants were unaware of the treatment they received. Blinding was maintained using a sham laser guide beam for the iontophoresis group while the laser device remained inactive [17] (Figure 1).

### **Inclusion Criteria:**

- Age greater than 18 years.
- Presence of at least 20 natural teeth.
- Complaint of dental sensitivity.
- A minimum score of 3 on the VAS following air blast stimulation tests.

- Presence of teeth with non-carious cervical lesions (NCCL) and/or gingival recession. [18].

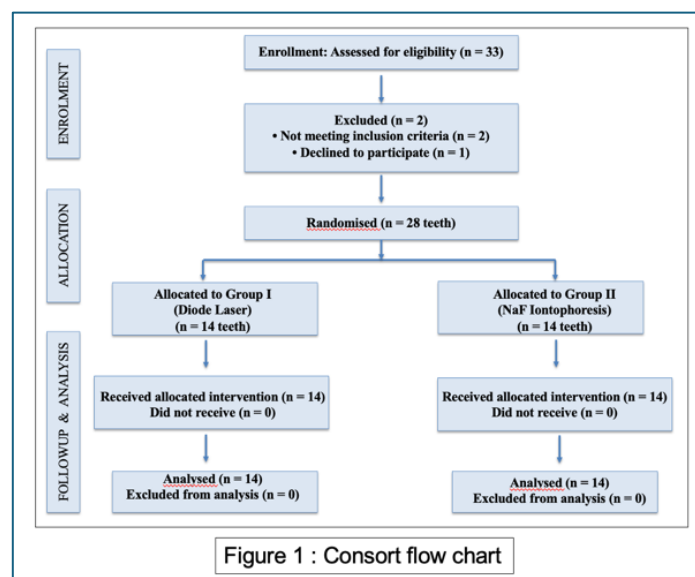
**Exclusion Criteria:**

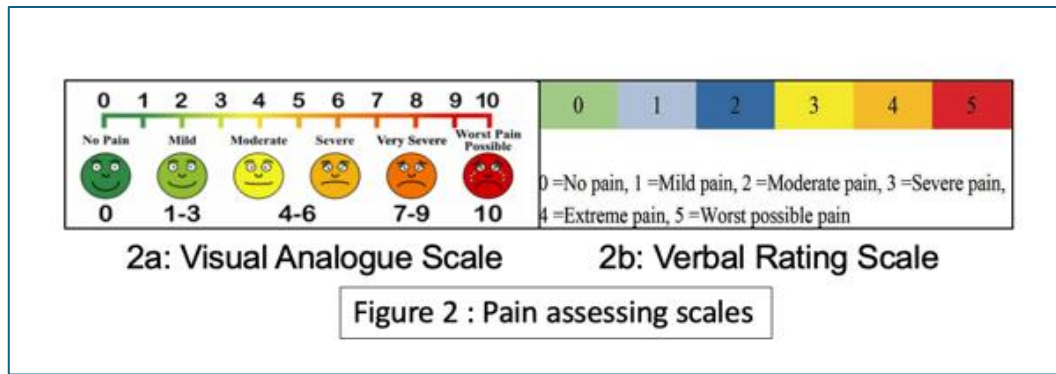
- Teeth exhibiting caries, cracks, pulpal inflammation, cervical restorations, broken enamel, or undergoing fixed orthodontic treatment.
- Pain similar to cervical dentin hypersensitivity (CDH) caused by other dental conditions.
- History of desensitizing treatments (including toothpaste, blocking agents, or bleaching) in the past six months.
- Pregnancy or lactation.
- Smoking habits.
- Poor diet with high consumption of sour and acidic foods [19].

**Evaluation of pain and DH:**

Pain was assessed using 10-point VAS and Verbal Rating Scale (VRS 0–5). Teeth were isolated with cotton rolls and air blast (1 cm distance, 2 s, 40 psi) applied to cervical third [20,21].

Pain perception was assessed using a 10-point Visual Analogue Scale (VAS) and a Verbal Rating Scale (VRS, 0–5). For VAS, patients marked their discomfort on a horizontal line ranging from 0 (no pain) to 10 (worst pain). For VRS, patients categorized pain as “no pain,” “mild,” “moderate,” “severe,” “very severe,” or “worst pain,” which was then recorded numerically. To evaluate dentinal hypersensitivity, teeth were isolated using cotton rolls placed mesially and distally to prevent false positives. An air blast test was performed using a dental unit syringe directed at the cervical one-third of the tooth from a distance of 1 cm for 2 seconds at 40 psi. Pain scores were recorded immediately using VAS and VRS (Figure 2).





**Treatment procedure:**

Twenty-eight patients with dentinal hypersensitivity due to non-carious cervical lesions (abrasion, attrition, erosion or abfraction) or periodontal disease were enrolled after written informed consent. All participants received Phase I periodontal therapy comprising scaling and root planing with personalised oral hygiene instructions. Patients were randomly allocated to two treatment groups by block randomisation (block size = 4) using a computer-generated sequence (Efird 2011) [22]. Allocation concealment was achieved with sequentially numbered, opaque, sealed envelopes opened only at the time of assignment. The trial was reported in accordance with the CONSORT 2010 Statement (Schulz et al. 2010) [23].

**Group I – Diode Laser desensitization**

Dentinal hypersensitivity was treated with a 980-nm diode laser (H1 Smart Soft Tissue Diode Laser, Pioon Medical Technology Co., Ltd., China) operated in non-contact continuous mode at 0.5 W (0.04 W/cm<sup>2</sup>). After isolation with cotton rolls (Hahnemann Laboratories, India), each tooth received three 20-second exposures (energy density 4 J/cm<sup>2</sup> per spot; spot diameter 0.8 mm). Both operator and patient wore Pioon laser safety goggles, and all procedures were performed in a designated laser workspace. Hypersensitivity was assessed using the Visual Analog Scale (VAS) and Verbal Rating Scale (VRS) immediately after treatment and at 1-week and 2-week follow-ups (Figure 3a).

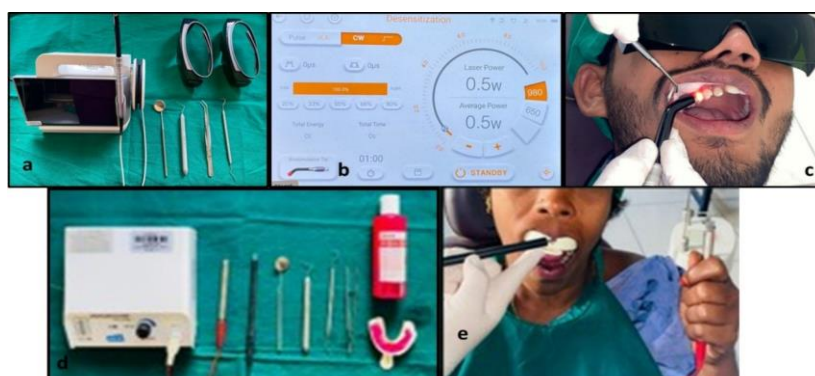


Figure 3: (a) Depict the Laser unit used, (b) shows the settings used and (c) shows the procedure performing on patient whereas (d) depict the armamentarium used in iontophoresis and (e) shows the method the placement of tray in patient.

## Group II – Iontophoresis with Fluoride Gel

Dentinal hypersensitivity was treated with a dental iontophoresis device (Jonofluor® Praxis Master, Dental Medical, Italy) using 1.23% acidulated phosphate fluoride (APF) gel (Zodenta, India). After isolation and drying, a sponge tray with a thin layer of APF gel was placed on the affected surfaces. Patients held the red-spiraled electrode while the black-spiraled electrode was inserted into the tray. A 2.5 mA current was applied for 2 minutes, after which the tray and electrodes were removed. Hypersensitivity was assessed using the Visual Analog Scale (VAS) and Verbal Rating Scale (VRS) immediately after treatment and at 1-week and 2-week follow-ups [24] (Figure 3b).

### Statistical analysis:

Data were entered into Microsoft Excel and imported into the Statistical Package for the Social Sciences (SPSS) version 23 for analysis (IBM Corp., Armonk, NY, USA) [25]. Qualitative variables were presented as frequencies and percentages, and quantitative variables as means  $\pm$  standard deviations. Paired t-tests were performed to assess intra-group changes in mean VAS scores from baseline to subsequent time points, and independent t-tests were performed for inter-group comparisons at each time point. A p-value  $<0.05$  was considered statistically significant and  $<0.001$  highly significant.

### Results:

On intra-group comparison of Group I (Diode Laser), the mean VAS scores were  $7.14 \pm 1.29$  at baseline and remained  $7.14 \pm 1.29$  immediately post-treatment ( $p = 1.000$ ). Significant reductions occurred at 1 week ( $0.79 \pm 1.12$ ,  $p < 0.001$ ) and 2 weeks ( $0.14 \pm 0.36$ ,  $p < 0.001$ ) post – operatively compared to baseline. Mean VRS scores were  $3.29 \pm 0.61$  at baseline, unchanged immediately post-treatment ( $3.29 \pm 0.61$ ,  $p = 1.000$ ), and decreased at 1 week ( $0.43 \pm 0.76$ ,  $p < 0.001$ ) and 2 weeks ( $0.14 \pm 0.36$ ,  $p < 0.001$ ) post – operatively (Table 1 and 2).

On intra-group comparison of Group II (NaF Iontophoresis), VAS scores decreased from  $7.79 \pm 0.89$  at baseline to  $5.64 \pm 1.01$  immediately post-treatment ( $p < 0.001$ ),  $1.07 \pm 1.49$  at 1 week ( $p < 0.001$ ) and  $0.93 \pm 1.27$  at 2 weeks ( $p < 0.001$ ) post – operatively. VRS scores decreased

from  $3.93 \pm 0.73$  at baseline to  $2.21 \pm 0.70$  immediately post-treatment ( $p < 0.001$ ),  $0.64 \pm 0.84$  at 1 week ( $p < 0.001$ ) and  $0.57 \pm 0.76$  at 2 weeks ( $p < 0.001$ ) post – operatively (Table 3 and 4).

On inter-group comparison, no significant difference in VAS scores was observed at baseline ( $p = 0.138$ ). Immediately post-treatment, Group II showed significantly lower VAS scores than Group I ( $p = 0.002$ ). At 1 week post – operative the groups were comparable ( $p = 0.572$ ). At 2 weeks post – operatively Group I had lower VAS scores ( $p = 0.035$ ). For VRS, baseline difference was  $p = 0.018$ . Immediately post-treatment Group II had lower VRS ( $p < 0.001$ ). At 1 week post – operatively both groups were comparable ( $p = 0.485$ ). At 2 weeks post – operatively Group I had lower VRS ( $p = 0.067$ ) (Graph 1 and 2).

**Table 1 depict the comparison of mean Visual Analogue Scale in Group 1 at different time intervals**

Time intervals		Visual Analogue Scale Laser Desensitization (Group 1)		
		Mean ± SD	Mean ± SD	P-Value
Baseline	Immediate post-operative	$7.14 \pm 1.29$	$7.14 \pm 1.29$	1.0000#
Baseline	1 Week	$7.14 \pm 1.29$	$0.79 \pm 1.12$	<0.001*
Baseline	2 weeks	$7.14 \pm 1.29$	$0.14 \pm 0.36$	<0.001*
Immediate post-operative	1 Week	$7.14 \pm 1.29$	$0.79 \pm 1.12$	<0.001*
Immediate post-operative	2 weeks	$7.14 \pm 1.29$	$0.14 \pm 0.36$	<0.001*
1 Week	2 weeks	$0.79 \pm 1.12$	$0.14 \pm 0.36$	<0.001*

$P < 0.05$  was considered statistically significant, #indicates non-significant, \* indicate significance, VAS- visual analogue scale, SD- standard deviation

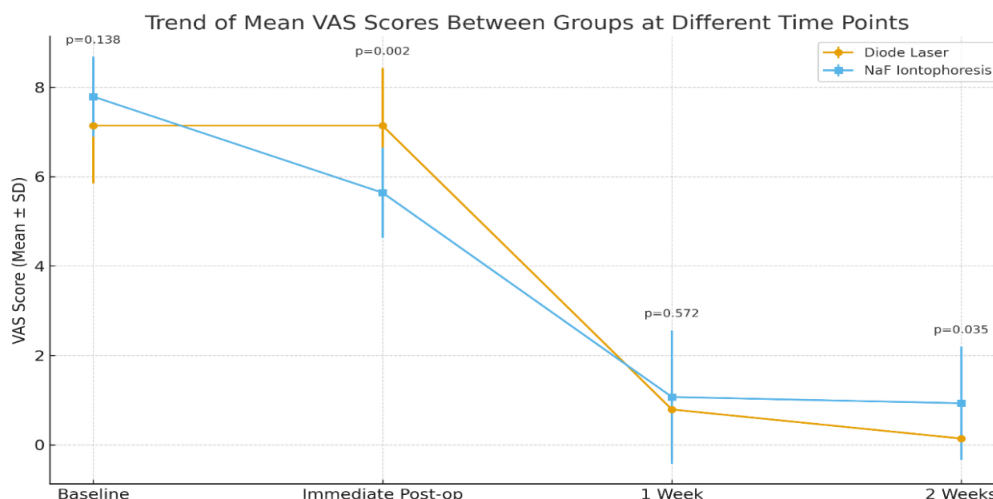


Figure Figure 4: VAS Comparison (Diode Laser vs NaF Iontophoresis). Error bars represent SD; p-values for inter-group comparisons annotated on the figure.

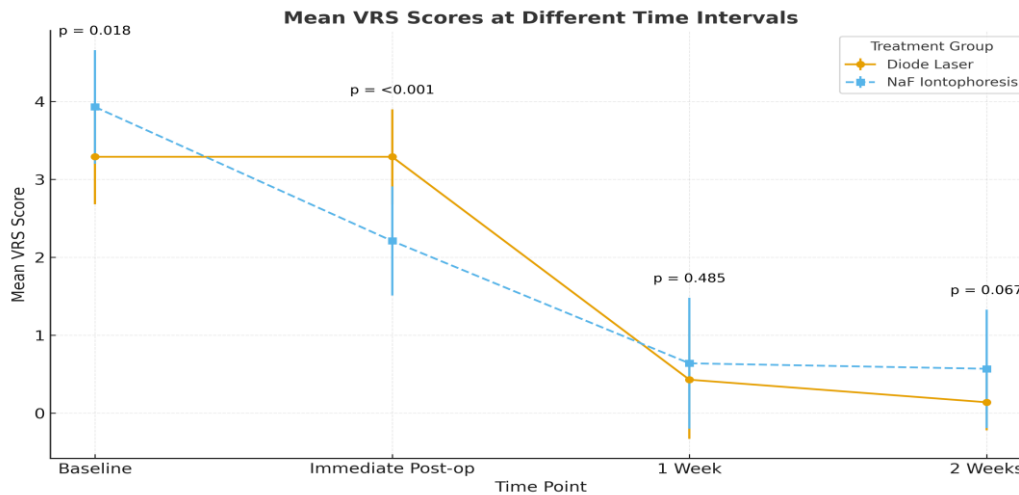


Figure 5. VRS Comparison (Diode Laser vs NaF Iontophoresis). Error bars represent SD; p-values for inter-group comparisons annotated on the figure.

Table 2 Depict the comparison of Mean Verbal Rating Scale in Group 1 at different time intervals

Time intervals		VRS Laser (Group 1)	Desensitization	
		Mean ± SD	Mean ± SD	P-Value
Baseline	Immediate post-operative	3.29 ± 0.61	3.29 ± 0.61	1.0000#
Baseline	1 Week	3.29 ± 0.61	0.43 ± 0.76	<0.001*
Baseline	2 weeks	3.29 ± 0.61	0.14 ± 0.36	<0.001*
Immediate post-operative	1 Week	3.29 ± 0.61	0.43 ± 0.76	<0.001*
Immediate post-operative	2 weeks	3.29 ± 0.61	0.14 ± 0.36	<0.001*
1 Week	2 weeks	0.43 ± 0.76	0.14 ± 0.36	0.2150#

P<0.05 was considered statistically significant, #indicates non-significant, \* indicate significance, VRS- verbal rating scale, SD- standard deviation, # indicates non-significant

**Table 3 Depict the Comparison of Mean Visual Analogue Scale in Group 2 at different time intervals**

		Visual Analogue Scale (Iontophoresis-Group 2)		
		Mean ± SD	Mean ± SD	P-Value
Baseline	Immediate post-operative	7.79 ± 0.89	5.64 ± 1.01	<0.001*
Baseline	1 Week	7.79 ± 0.89	1.07 ± 1.49	<0.001*
Baseline	2 weeks	7.79 ± 0.89	0.93 ± 1.27	<0.001*
Immediate post-operative	1 Week	5.64 ± 1.01	1.07 ± 1.49	<0.001*
Immediate post-operative	2 weeks	5.64 ± 1.01	0.93 ± 1.27	<0.001*
1 Week	2 weeks	1.07 ± 1.49	0.93 ± 1.27	<0.001*

p<0.05 was considered statistically significant, #indicates non-significant, \* indicate significance, VAS-visual analogue scale

**Table 4 Depict the comparison of Mean Verbal Rating Scale in Group 2 at different time intervals**

		Verbal Rating Scale (Iontophoresis Group)		
		Mean ± SD	Mean ± SD	P-Value
Baseline	Immediate post-operative	3.93 ± 0.73	2.21 ± 0.7	<0.001*
Baseline	1 Week	3.93 ± 0.73	0.64 ± 0.84	<0.001*
Baseline	2 weeks	3.93 ± 0.73	0.57 ± 0.76	<0.001*
Immediate post-operative	1 Week	2.21 ± 0.7	0.64 ± 0.84	<0.001*
Immediate post-operative	2 weeks	2.21 ± 0.7	0.57 ± 0.76	<0.001*
1 Week	2 weeks	0.64 ± 0.84	0.57 ± 0.76	<0.001*

p<0.05 was considered statistically significant, #indicates non-significant, \* indicate significance, Verbal Rating Scale

**Discussion:**

The present study compared two clinically relevant in-office modalities to determine their relative efficacy and duration of effect in managing dentinal hypersensitivity. This study was aimed to compare the effectiveness of diode laser and 1.23% APF gel iontophoresis in reducing

dentinal hypersensitivity over a two-week period using the VAS & VRS scores. The baseline VAS and VRS scores were comparable between the two groups, ensuring a uniform starting point for intervention. The findings highlight differences in onset and persistence of desensitizing effects between diode laser and NaF iontophoresis. Both diode laser therapy and NaF iontophoresis effectively reduced dentinal hypersensitivity, yet the former achieves more sustained reduction through photobiomodulation, and the latter provides faster immediate relief via ionic deposition.

The present study evaluated the comparative efficacy of diode laser therapy versus 1.23% acidulated phosphate fluoride (APF) gel iontophoresis in reducing dentinal hypersensitivity over a two-week period, using both Visual Analog Scale (VAS) and Verbal Rating Scale (VRS) scores. Baseline measurements were comparable between the two groups, providing a uniform starting point for intervention. The results revealed notable differences in both the onset and duration of desensitizing effects between the modalities. While both diode laser therapy and NaF iontophoresis significantly reduced hypersensitivity, diode laser treatment conferred more sustained relief, likely due to photobiomodulation, whereas NaF iontophoresis provided rapid immediate relief through ionic deposition.

Intra-group analysis showed that diode laser (**Group I**) treatment did not significantly reduce sensitivity immediately post-treatment, but a marked reduction was evident at 1 week and further at 2 weeks, indicating a cumulative and progressive effect, likely due to photobiomodulation, tertiary dentin formation or neural desensitization mechanisms [26, 27]. In contrast, NaF iontophoresis (**Group II**) produced an immediate and significant reduction in VAS and VRS scores, which persisted at 1 and 2 weeks, reflecting rapid tubule occlusion by calcium fluoride formation [28, 29]. These findings are consistent with previous studies reporting both laser therapy and fluoride-based iontophoresis as effective modalities for dentinal hypersensitivity [30, 31].

Inter-group analysis showed that immediately post-treatment, NaF iontophoresis achieved a greater reduction in sensitivity compared to diode laser. By 2 weeks, diode laser demonstrated slightly lower VAS scores, while VRS scores were comparable between groups, indicating equivalent long-term efficacy. These findings highlight the immediate analgesic effect of NaF iontophoresis versus the progressive and sustained effect of diode laser, reflecting their distinct mechanisms—rapid dentin tubule occlusion with iontophoresis versus secondary dentin deposition and nerve desensitization with laser therapy [32, 33]. The mechanisms underlying these effects are

distinct. 1.23% Sodium fluoride iontophoresis facilitates the penetration of fluoride ions into dentinal tubules, where they react with calcium to form calcium fluoride physically blocking fluid movement and rapidly reducing sensitivity [29]. Diode laser therapy acts through photobiomodulation, stimulating tertiary dentin formation and modulating nerve excitability, producing a delayed yet sustained reduction in DH [34, 35].

Several studies have reported similar findings. Kumar et al. [3] observed significant reductions in DH with both diode laser and NaF gel. Jalaluddin and Almalki [11] reported enhanced immediate pain relief using iontophoresis, while Klinke et al. [26] demonstrated progressive long-term efficacy of diode laser. Although direct comparative studies are limited, the present study provides clinical evidence highlighting the differences in onset and duration of efficacy between these interventions. The present study also emphasizes the importance of stepwise management of DH. Initial home care measures should be encouraged, with in-office interventions reserved for cases with persistent sensitivity. This approach enhances patient compliance and overall treatment effectiveness [36, 37].

Limitations of this study include a relatively short follow-up period of 2 weeks and the sample size restricted to 28 patients. Future studies should include longer follow-up durations and larger cohorts to validate the sustained effectiveness and external validity of both modalities. Additionally, while this study employed sham blinding for iontophoresis, complete double-blinding was not feasible, which may influence patient-reported outcomes.

### **Clinical Relevance:**

The combined use of VAS and VRS allowed for a comprehensive assessment of dentin hypersensitivity, capturing both subjective and objective dimensions of pain. Patient-friendly tools such as VRS supported improved patient engagement and understanding during treatment. Both diode laser and iontophoresis provided effective, minimally invasive management of hypersensitivity. The procedures were brief and well-tolerated, indicating their feasibility in routine clinical practice.

### **Conclusion:**

Sodium fluoride iontophoresis and diode laser therapy both effectively reduce dentinal hypersensitivity. 1.23% NaF iontophoresis provides immediate relief, while diode laser offers progressive and sustained improvement. These findings support the integration of either

modality into a stepwise clinical management plan for DH, tailored to patient needs and response.

## Acknowledgements: Nil

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