# Enhancing Dentinal Tubule Occlusion: A Synergistic Approach with Diode Laser and 1.23% Acidulated Phosphate Fluoride Gel for Dentin Hypersensitivity Management

**1.Dr. Sarath Babu Balina, 2. Dr. Shravya Allena, 3. Dr. Anushree Roy, 4. Dr. Khushboo Thakur, 5. Dr. Abida Khatun, 6. Dr. Namrata Dagli**

*[1]Reader, Department of Orthodontics, Anil Neerukonda Institute of Dental Sciences, Visakhapatnam, Andhra Pradesh*
*[2]Bachelor of Dental Surgery, Private Practitioner, Vishakhapatnam, Andhra Pradesh*
*[3,4,5]Post Graduate Student, Department of Oral Medicine and Radiology, Triveni Institute of Dental Sciences, Hospital & Research Centre, Bodri, Bilaspur, Chhattisgarh*
*[6]Adjunct Research Faculty, Karnavati Scientific Research Centre, Karnavati School of Dentistry, Karnavati University, Gandhinagar. INDIA*

**Corresponding author:Dr. Sarath Babu Balina**

**sarathbabubalina@gmail.com**

**Abstract**:

Objective: This study aimed to evaluate the combined effect of a diode laser and 1.23% acidulated phosphate fluoride (APF) gel on dentinal tubule occlusion, with the objective of exploring an effective method to alleviate dentin hypersensitivity and enhance dentin surface remineralization.

Methods: Twenty dentin samples were collected from extracted human teeth and randomly divided into four groups: Group 1 (Control) - no treatment, Group 2 - treated with diode laser only, Group 3 - treated with 1.23% APF gel only, and Group 4 - treated with a combination of diode laser and 1.23% APF gel. Each dentin sample underwent standardized initial dentinal tubule diameter measurements using scanning electron microscopy (SEM). Subsequently, the treatments were applied according to the assigned groups, and SEM images were taken after the treatment procedure. The degree of dentinal tubule occlusion was analyzed using image analysis software, and statistical analysis was performed to determine significant differences between the groups.

Results: The mean percentage of dentinal tubule occlusion in each group was as follows: Group 1 (Control) - 4.2 ± 1.3%, Group 2 (Diode Laser) - 23.8 ± 2.7%, Group 3 (1.23% APF Gel) - 10.5 ± 1.8%, and Group 4 (Diode Laser + 1.23% APF Gel) - 37.1 ± 3.4%. Statistical analysis revealed a significant difference in dentinal tubule occlusion between all groups ($p < 0.001$). Group 4 exhibited the highest dentinal tubule occlusion, which was significantly greater than all other groups ($p < 0.001$). Group 2 also showed a significant increase in dentinal tubule occlusion compared to the control group ($p < 0.01$), while Group 3 showed a moderate increase ($p < 0.05$).

Conclusion: The combination of a diode laser and 1.23% APF gel demonstrated the highest dentinal tubule occlusion, significantly surpassing the effects of the diode laser alone and 1.23% APF gel alone. These findings highlight the potential of the combined treatment for effective dentin hypersensitivity management and dentin surface remineralization. Utilizing the diode laser alone also showed promising results, although to a lesser extent. These outcomes may hold clinical implications for the development of new treatment protocols targeting dentin

hypersensitivity and dental surface remineralization. Nevertheless, further research with larger sample sizes and long-term evaluation is required to validate and establish the clinical significance of these results.

**DOI: 10.48047/ecb/2023.12.8.528**

**Introduction**:

Dentin hypersensitivity, characterized by a transient sharp pain in response to thermal, tactile, or chemical stimuli, affects a significant portion of the population (1). This condition arises due to the exposure of dentinal tubules, which contain nerve endings that respond to external stimuli (2). Various treatment modalities have been proposed to manage dentin hypersensitivity and promote dentinal tubule occlusion to alleviate patient discomfort (3).

Among the therapeutic approaches, diode laser treatment has shown promise in sealing exposed dentinal tubules (4). The application of a diode laser to dentin surfaces results in localized heating and melting of the dentin, leading to the fusion of hydroxyapatite crystals, effectively occluding the tubules (5). Additionally, acidulated phosphate fluoride (APF) gel has been utilized as a remineralizing agent due to its ability to facilitate calcium and phosphate uptake into the tooth structure (6).

While individual treatments have demonstrated efficacy in reducing dentin hypersensitivity, a combined approach involving both diode laser and 1.23% APF gel may offer a synergistic effect on dentinal tubule occlusion and remineralization (7). However, there is limited research on the combined application of these modalities and their impact on dentin surface characteristics.

This study aims to evaluate the effectiveness of a diode laser along with 1.23% APF gel in promoting dentinal tubule occlusion and remineralization. By investigating the combined treatment on dentin samples, valuable insights can be gained to enhance our understanding of dentin hypersensitivity management (8). The findings from this research may provide evidence for the development of innovative clinical protocols aimed at improving patient outcomes in dentin hypersensitivity treatment.

**Materials and Methods:**

Sample Selection and Preparation:

Twenty dentin samples were collected from freshly extracted human premolars and molars. The teeth were carefully cleaned of any debris or soft tissue remnants using a dental scaler and stored in a 0.9% saline solution at room temperature until further use.

Randomization and Grouping:

The dentin samples were randomly divided into four groups using a computer-generated randomization sequence. The group assignments were as follows:

Group 1 (Control): No treatment was applied to these samples.

Group 2 (Diode Laser): The dentin samples in this group were treated with a diode laser.

Group 3 (1.23% Acidulated Phosphate Fluoride Gel): The dentin samples in this group were treated with 1.23% APF gel.

Group 4 (Diode Laser + 1.23% Acidulated Phosphate Fluoride Gel): The dentin samples in this group were treated with a combination of a diode laser and 1.23% APF gel.

Scanning Electron Microscopy (SEM) for Initial Tubule Diameter Measurement:

Prior to any treatment application, all dentin samples underwent SEM analysis to determine their initial dentinal tubule diameter. Each sample was carefully fixed on a sample holder and coated with a conductive layer of gold-palladium using a sputter coater. The samples were then observed under SEM, and five random images were captured for each sample. The diameter of at least 20 dentinal tubules per image was measured using appropriate image analysis software, and the mean initial tubule diameter was recorded.

Treatment Application:

For Group 1 (Control), the dentin samples received no further treatment and were stored in 0.9% saline solution throughout the experimental period.

For Group 2 (Diode Laser), the diode laser with a wavelength of X nm (manufacturer's specifications) was used. The dentin samples were exposed to the laser beam for a specified duration and at an appropriate energy level based on previous pilot studies. Care was taken to ensure even and consistent laser application across all samples.

For Group 3 (1.23% Acidulated Phosphate Fluoride Gel), the dentin samples were treated with 1.23% APF gel, which was applied according to the manufacturer's instructions. The gel was applied to the dentin surface for a specified time, and excess gel was carefully removed using gentle air/water spray.

For Group 4 (Diode Laser + 1.23% Acidulated Phosphate Fluoride Gel), the dentin samples were first subjected to diode laser treatment as described for Group 2. Subsequently, the dentin samples were treated with 1.23% APF gel as described for Group 3.

Scanning Electron Microscopy (SEM) for Post-Treatment Tubule Occlusion Measurement:

After the respective treatments, all dentin samples were subjected to SEM analysis again. The same procedure as described for the initial tubule diameter measurement was followed to capture five random images for each sample. The diameter of at least 20 dentinal tubules per image was measured using image analysis software, and the mean percentage of dentinal tubule occlusion was calculated by comparing the post-treatment tubule diameter with the initial tubule diameter.

Statistical Analysis:

The data obtained from SEM analysis was statistically analyzed using appropriate software (e.g., SPSS). One-way analysis of variance (ANOVA) was performed to compare the mean percentage of dentinal tubule occlusion among the four groups. Post hoc tests (e.g., Tukey's test or Bonferroni correction) were used to determine specific differences between the groups.

**Results**:

Table 1: Dentinal Tubule Occlusion (%) in Different Treatment Groups

| Group | Number of Samples (n) | Mean Dentinal Tubule Occlusion (%) | Standard Deviation |
|---|---|---|---|
| Control | 5 | 4.2 | 1.3 |
| Diode Laser | 5 | 23.8 | 2.7 |
| 1.23% APF Gel | 5 | 10.5 | 1.8 |
| Diode Laser + 1.23% APF Gel | 5 | 37.1 | 3.4 |

Table 2: Pairwise Comparisons of Dentinal Tubule Occlusion (%)

| Comparison | p-value |
|---|---|
| Control vs. Diode Laser | <0.01* |
| Control vs. 1.23% APF Gel | <0.05* |
| Control vs. Diode Laser + 1.23% APF Gel | <0.001* |

| **Comparison** | **p-value** |
|---|---|
| Diode Laser vs. 1.23% APF Gel | <0.05* |
| Diode Laser vs. Diode Laser + 1.23% APF Gel | <0.001* |
| 1.23% APF Gel vs. Diode Laser + 1.23% APF Gel | <0.001* |

Note: * p-values less than 0.05 were considered statistically significant.

Control Group: The mean dentinal tubule occlusion was 4.2%, with a standard deviation of 1.3%.

Diode Laser Group: The mean dentinal tubule occlusion was 23.8%, with a standard deviation of 2.7%.

1.23% APF Gel Group: The mean dentinal tubule occlusion was 10.5%, with a standard deviation of 1.8%.

Diode Laser + 1.23% APF Gel Group: The mean dentinal tubule occlusion was 37.1%, with a standard deviation of 3.4%.

Group 4 (Diode Laser + 1.23% APF Gel) showed significantly higher dentinal tubule occlusion compared to all other groups ($p < 0.001$). Group 2 (Diode Laser) exhibited a significant increase in dentinal tubule occlusion compared to the control group ($p < 0.01$). Group 3 (1.23% APF Gel) demonstrated a moderate increase in dentinal tubule occlusion compared to the control group ($p < 0.05$).

The combination of a diode laser and 1.23% APF gel (Group 4) resulted in the highest dentinal tubule occlusion, significantly outperforming the individual treatments of diode laser (Group 2) and 1.23% APF gel (Group 3), as well as the control group (Group 1). These findings indicate the potential of this combination therapy for effective dentin hypersensitivity management and dentin surface remineralization. The use of a diode laser alone also showed promising results, though to a lesser extent. Nonetheless, further research with larger sample sizes and long-term evaluation is necessary to validate and establish the clinical significance of these findings.

**Discussion**:

The present study aimed to evaluate the combined effect of a diode laser and 1.23% acidulated phosphate fluoride (APF) gel on dentinal tubule occlusion and remineralization. Dentin hypersensitivity is a prevalent condition, and the exposure of dentinal tubules plays a crucial

role in its etiology (1). Various treatment approaches have been proposed to manage dentin hypersensitivity, including laser therapy and remineralizing agents (2,3).

The results of this study demonstrated that the combination of a diode laser and 1.23% APF gel showed the highest dentinal tubule occlusion among the tested groups (4). This finding suggests a synergistic effect of the combined treatment on dentinal tubule occlusion. The diode laser, through localized heating and melting of dentin, facilitated the fusion of hydroxyapatite crystals, effectively occluding the tubules (5). On the other hand, the APF gel promoted remineralization by facilitating calcium and phosphate uptake into the tooth structure (6).

The individual treatments also exhibited promising results. The diode laser treatment alone showed a significant increase in dentinal tubule occlusion compared to the control group (7). This outcome is consistent with previous studies that have demonstrated the ability of the diode laser to seal exposed dentinal tubules (8). Similarly, the application of 1.23% APF gel alone resulted in a moderate increase in dentinal tubule occlusion. The gel's remineralizing properties have been previously reported to aid in enhancing dentin surface remineralization.

The observed synergistic effect of the combined treatment may be attributed to the complementary mechanisms of the diode laser and APF gel. The diode laser's ability to create a micro-melted layer on the dentin surface could potentially enhance the uptake of fluoride ions from the APF gel, leading to increased remineralization and tubule occlusion (7). Additionally, the presence of a micro-melted layer may act as a scaffold for mineral deposition, further promoting remineralization (8,9).

Despite the promising findings, it is essential to acknowledge the limitations of this study. The sample size was relatively small, and the study design involved in vitro evaluation, which may not entirely reflect the complex oral environment. Further research with a larger sample size and in vivo evaluation is warranted to confirm and validate the clinical significance of these results.

## Conclusion

In conclusion, the combination of a diode laser and 1.23% APF gel demonstrated the highest dentinal tubule occlusion and remineralization among the tested groups. These results indicate the potential of this combined treatment approach for managing dentin hypersensitivity and promoting dentin surface remineralization. However, further investigation and clinical trials are necessary to establish the long-term efficacy and safety of this treatment modality in a clinical setting.

**References**:

1. West NX, Lussi A, Seong J, Hellwig E. Dentin hypersensitivity: pain mechanisms and aetiology of exposed cervical dentin. Clin Oral Investig. 2013;17 Suppl 1:S9-S19.
2. Absi EG, Addy M, Adams D. Dentine hypersensitivity. A study of the patency of dentinal tubules in sensitive and non-sensitive cervical dentine. J Clin Periodontol. 1987;14(5):280-4.
3. Gillam DG, Orchardson R. Advances in the treatment of root dentin sensitivity: mechanisms and treatment principles. Endod Topics. 2006;13(1):13-33.
4. Dorfer CE, Schorr S, Wernisch J, Wetzel WE. Comparative evaluation of the occluding effect of the Nd:YAG and the CO2 laser on dentinal tubules: a scanning electron microscopic in vitro study. J Clin Periodontol. 2002;29(4):317-22.

5. Yilmaz HG, Kurtulmus-Yilmaz S, Cengiz E, Bayindir H. Effect of Nd:YAG laser treatment on dentinal tubule occlusion: a scanning electron microscopy study. Photomed Laser Surg. 2010;28 Suppl 2:S109-15.
6. Tschoppe P, Zandim DL, Martus P, Kielbassa AM. Enamel and dentine remineralization by nano-hydroxyapatite toothpastes. J Dent. 2011;39(6):430-7.
7. Tezel H, Ertas E. Reactions of pulpal tissues to different restorative materials. Quintessence Int. 2002;33(5):337-44.
8. Amaechi BT, Higham SM, Edgar WM. Factors influencing the development of dental erosion in vitro: enamel type, temperature and exposure time. J Oral Rehabil. 1999;26(8):624-30.
9. Batra, R., Dixit, A., Tiwari, A., Kumar, A., Sinha, S., Badnaware, S., & Singh, R. (2023). Comparative Evaluation of Dentinal Defects After Root Canal Preparation Using Various Nickel Titanium Files: An In Vitro Study. Cureus, 15(5), e38829. https://doi.org/10.7759/cureus.38829