



Comparison of the Effects of Gluma Gel, Sensodyne Repair and Protect Toothpaste, and an 810 nm Low Power Diode Laser on the Closure of Dentinal Tubules: An *In Vitro* Study

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Abstract

Introduction: One of the common problems among dental patients is tooth hypersensitivity. There are various treatments for hypersensitivity, such as gels, solutions, toothpaste, and laser treatments. This report examined the effect of three treatments, namely 810 nm wavelength diode laser, Gluma gel, and Sensodyne Repair and Protect toothpaste, on tooth hypersensitivity.

Methods: This experimental survey selected 40 premolars free of caries, fractures, restorations, root canal therapy, or wear. The enamel of the midline in the cervical part of the buccal surface was removed by a bur (the area was 2*2 mm and the depth was 2 mm), and the samples were then prepared and divided into four groups. Sensodyne Repair and Protect toothpaste, Gluma gel, and an 810 nm diode laser with 0.5 W power were applied to three groups of teeth. The samples were analyzed by using a field emission scanning electron microscope (FE-SEM). The data from the occluded dentinal tubules, partially occluded tubules, and open tubules were analyzed by using the Tamhane test.

Results: The amount of occluded dentinal tubules was $83.2 \pm 9\%$ in the laser group, $74.4 \pm 11.62\%$ in the Gluma group, $67.1 \pm 18\%$ in the Sensodyne group, and $15.03 \pm 3.39\%$ in the control group. The difference between the treatment groups and the control group was meaningful ($P < 0.05$). However, the difference between the Gluma group, the Sensodyne group, and the 810 nm laser group was not significant ($P > 0.05$).

Conclusion: The three treatments (810 nm diode laser, Gluma, and Sensodyne) were all effective in occluding dentinal tubules compared to the control group. However, there was no significant difference between these three treatment methods ($P > 0.05$).

Keywords: Dentin desensitizing agents; Gluma desensitizer; Laser; Dentin-bonding agents.



Introduction

One of the common issues in dentistry is tooth hypersensitivity, which is painful for patients, and it sometimes affects food choices and oral hygiene habits.¹ Dental sensitivity causes a sharp, sudden, and painful reaction of the tooth when it is exposed to cold, heat, chemical or mechanical stimulation, touch, or osmotic changes, and it cannot be attributed to other pathological cases.¹ In 1982, dentin sensitivity was considered a mystery because there was not enough information about it.² Today, however, various products are available to reduce the pain and discomfort caused by tooth sensitivity. One method of reducing sensitivity is the closure of dentinal tubules. Various substances are known for dentinal tubule closure, including sealants that stick to the teeth, such as fluoride varnish and bonding, other substances such as sodium

fluoride, stannous fluoride, bioactive glasses, and nerve desensitizers (potassium phosphate),^{3,4} and different lasers, for example, CO_2 , Er-YAG, Nd-YAG, and diode lasers.^{5,6} In the mid-1980s, the use of low-level lasers was introduced in treating dental hypersensitivity.⁷ The proposed method of action for low-level lasers in desensitizing teeth involves the stimulation of reparative dentin formation and dentinal tubule occlusion, which can help block fluid movement and reduce pain transmission. Analgesic effects through interference with pain signal transmission from the dental pulp and increased microcirculation and odontoblast activity within the dentin, which may contribute to desensitization. Compared to high-power laser treatments, low-power lasers are generally considered a more conservative, less invasive approach that can effectively reduce dentin hypersensitivity without causing

thermal damage to the pulp.^{8,9} Despite the existence of various treatment methods, dentin hypersensitivity still is an important matter with an uncertain prognosis,¹⁰ and there has not been a single treatment that can reduce pain in all cases.¹¹ Therefore, this survey proposes to examine and directly compare the effectiveness of three different desensitizing agents/technologies—a desensitizing agent (Gluma), a desensitizing toothpaste (Sensodyne), and a low-power laser treatment—in the rate of tubular closure.

Materials and Methods

Statistical Method

This experimental survey used one-way ANOVA in PASS II software, considering $\alpha=0.05$, $\beta=0.2$, an average standard deviation of 0.077, and an effect size of 0.57, with the minimum sample size needed in the study being 10 in each of the four groups. Simple random sampling was used to collect the sample.¹² A total of 40 premolar teeth were selected from newly extracted teeth for orthodontic purposes in people aged 12 to 25 years. The teeth with decay, restoration, root treatment, fracture, wear, or dental anomalies were excluded from the study.⁵

Sample Preparation

Debris was removed by Gracie Periodontal Curette No. 5-6 (HU-Friedy, USA).⁵ The teeth were polished with fluoride-free powder of pumice (Maquira, Brazil) using a rubber cap attached to the handpiece for 10 seconds, washed with distilled water for 15 seconds, and then exposed to air to dry.⁶ The teeth were stored in a 10% formalin solution at room temperature.⁹ The prepared samples were coded and randomly divided into four groups: three treatment groups and one control group (each group included 10 teeth). The enamel samples with an area of 2×2 mm and a depth of 2 mm (the dimensions were checked by the Williams periodontal probe, Hu-

Friedy, USA) were removed in the midline of the cervical part of the buccal surface (diamond fissure bur No. 008, Teeskavan, Iran) (Figure 1). To flatten the cute surface, a flat-ended 12-blade conical carbide bur was used (No. 135, Vanetti-Dia, Tessin, Swiss).¹⁴ Prepared samples were first placed in a 17% EDTA solution (Nikdarman-Iran) for one minute to remove the smear layer and expose dentinal tubules.⁵ They were then washed with distilled water, dipped in a sodium hypochlorite solution for one minute, and washed again with distilled water. The samples were kept in distilled water until the treatments were applied.¹⁵

Study Groups

Group 1 (the control group, samples 1-10) consisted of 10 pieces of tooth that were kept in distilled water after immersion in a 17% EDTA solution for one minute, were not subjected to any intervention, and were thus considered the control group.^{5,12}

In group 2 (the Gluma group, samples 11-20), one drop of Gluma hypoallergenic gel (Heraeus Kulzer, Hanau, Germany) was applied with an applicator to the wet dentin surface in the mid-buccal area of the cervical part of the prepared teeth for 60 seconds, and the samples were then left for 30 seconds. To dry the Gluma on the surface, an air blower was slowly taken over the samples. The samples were washed with distilled water for 10 seconds.^{6,9,12} In group 3 (the Sensodyne group, samples 21-30), the samples were washed by using a toothbrush with a pea-sized amount of toothpaste on its surface (Smith Beecham LTD, EUCH CQ, UK). The bristles of the toothbrush were placed at a 90° angle to the tooth surface. This function was performed for two minutes a day (calculated with a stopwatch) for 14 days, and after each brushing, the samples were washed and stored in distilled water.¹² In group 4 (the 810 nm diode laser group, samples 31-40), the samples were continuously irradiated by an 810 nm diode

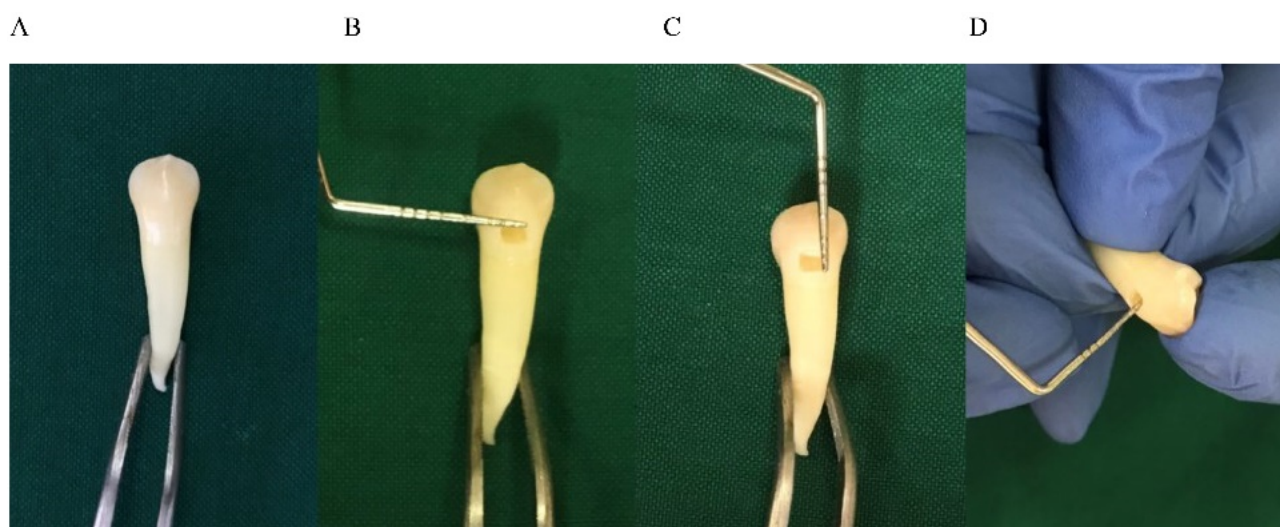


Figure 1. Sample Preparation Size and Depth. A) Sample premolar tooth before trimming. B) 2-mm long incision in the cervical midline. C) 2-mm wide incision in the cervical midline. D) 2-mm deep incision in the cervical midline

laser (Pulsar, Iran) with a power of 0.5 W, a low power head (1cm in diameter), and an energy density of 9.375 J/cm², for 15 seconds for three times, with the circular type of the movement and the speed movement of 2mm per second with an interval of 24 hours.¹⁶ The laser was irradiated tangentially (the head of the device was placed tangentially on the tooth surface with apico-coronal and mesiodistal rapid movements) on the mid-buccal surface of the cervical area (Figure 2).⁸

Field Emission Scanning Electron Microscope (FE-SEM)

To evaluate the degree of tubular closure, the FE-SEM microscope (Nikon, Japan) was used. Before preparing the samples to be placed in the SEM microscope, the crowns were cut from the root using a diamond burr (No. 008, Teeskavan, Iran).⁵ The samples were washed and then covered with a thin layer of gold with a thickness of 100 angstroms¹¹ (Figure 3), vacuumed in a vacuum device, and mounted and examined by a microscope. The microscope settings were set to 10 kV voltage and 5000 magnification.^{11,13}

Finally, photomicrographs with 2000 and 5000 magnifications were randomly prepared from the mid-buccal surface of the cervical region of the samples

(Figure 4). Due to the greater clarity of dentinal tubules in the images with a magnification of 5000, the total number of tubules, as well as open and closed tubules (both completely and partially), was manually counted and expressed as percentages, and the data were statistically analyzed by using the Tamhane test using PASS II software. The percentage of closed tubules (completely closed and partially closed) was obtained by dividing the total number of completely and partially closed tubules by the total number of dentinal tubules observed in the image, multiplied by 100.^{11,13} The tubules whose canal opening was completely closed were considered fully closed tubules, and those tubules whose opening diameter was reduced but the center was open were considered semi-closed tubules.⁹

Results

Based on the findings obtained from the statistical analysis, the highest mean rate of dentinal tubule closure was found in the laser group (under an 810 nm irradiation) ($83.2 \pm 9.2\%$), and the lowest rate of closure was found in the control group ($15.03 \pm 3.39\%$) (Table 1, Figures 5 and 6).

The groups were compared two by two by post hoc



Figure 2. Materials Used in This Study. A) Sensodyne Repair and Protect toothpaste and its application to the tooth. B) Diode laser 810 nm

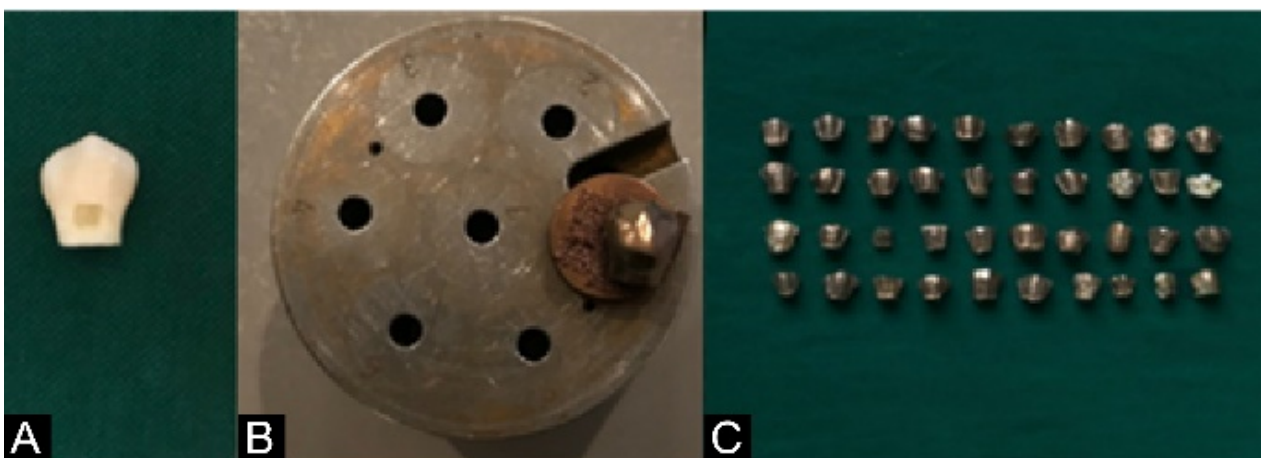


Figure 3. Sample Preparation for Gold Covering and Observing Under SEM Microscope. A) Prepared tooth for SEM microscope. B and C) Gold-covered samples

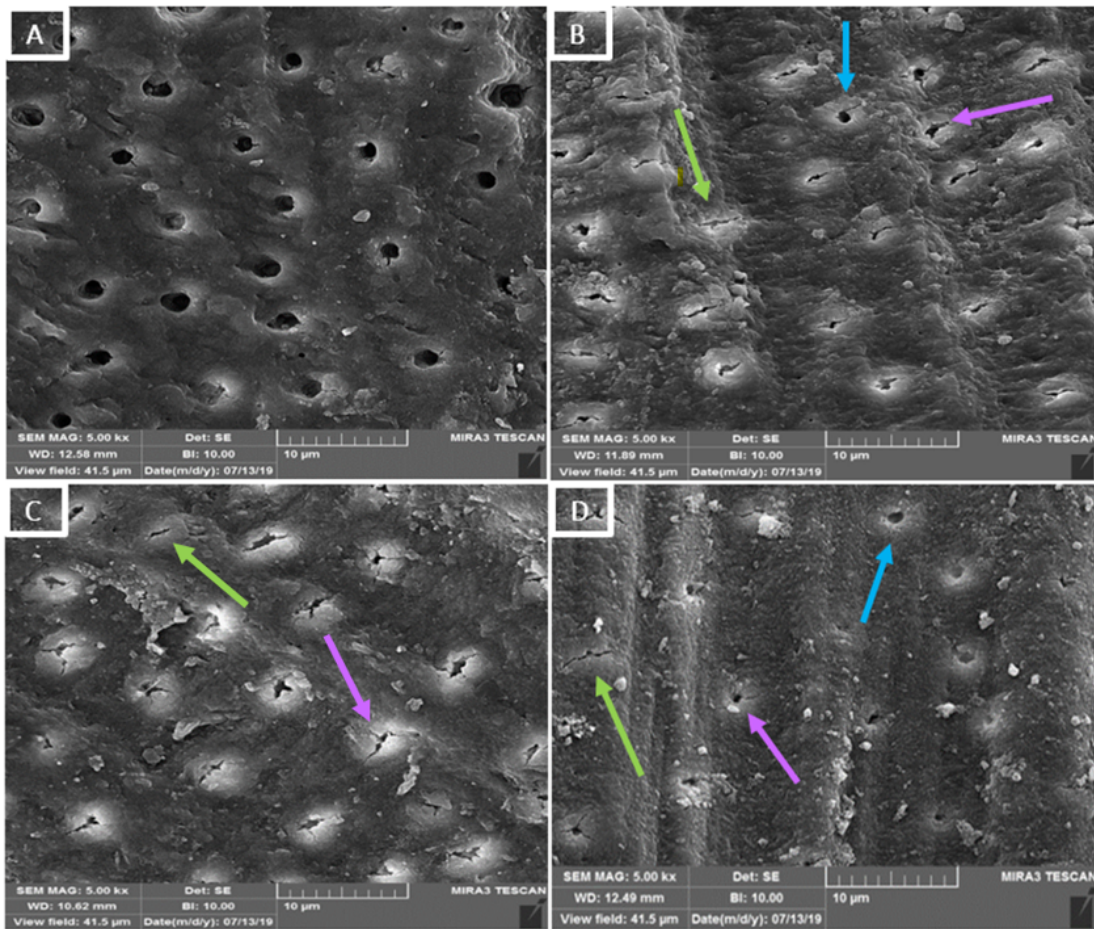


Figure 4. Photomicrographs With 2000 and 5000 Magnifications, Prepared From the Mid-buccal Surface of the Cervical Region of the Samples Showing Opened, Closed, and Semiclosed Tubules. A) The photomicrograph was prepared from one of the control group samples with open dental tubules. B) The Gluma group with closed tubules (green arrow), semi-closed tubules (purple arrow), and open tubules (blue arrow). C) The 810 nm laser group with closed (green arrow) and semi-closed (purple arrow) tubules. D) The Sensodyne group with closed tubules (green arrow), semi-closed tubules (purple arrow), and open tubules (blue arrow)

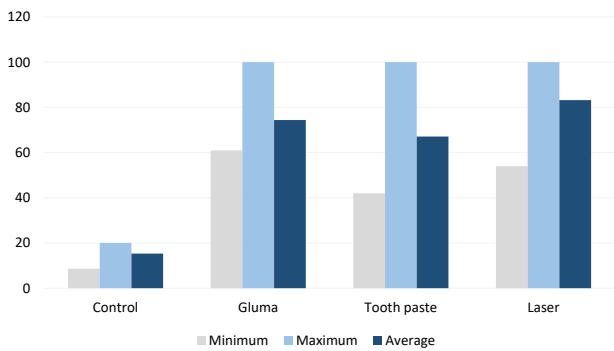


Figure 5. Results of the Study. The horizontal dimension consists of the study groups, and the vertical dimension consists of the percentage of the minimum, maximum, and mean in each group

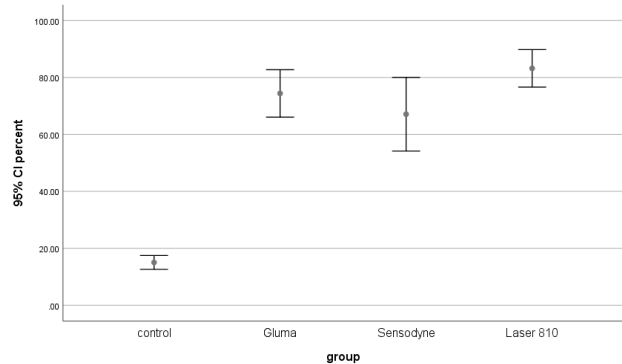


Figure 6. Comparison of the Percentage of Dental Tubule Closure in the Investigated Groups

Table 1. Results of the Study, Including the Number of Samples (10 Samples in Each Group) and the Percentage of Maximum, Minimum, Mean, and Standard Deviation

Study Groups	Number of Samples	Minimum	Maximum	Mean	Standard Deviation
Control	10	8.60	20	15.03	3.39
Gluma	10	61	100	74.40	11.62
Sensodyne	10	42	100	67.10	18.10
Laser	10	65	100	83.20	9.21

tests, and due to the abnormal distribution of the data, the Tamhane test was performed. According to the test results, there were no significant differences between the three experimental groups, namely Gluma, 810 nm diode laser, and Sensodyne ($P > 0.05$), while there was a considerable difference between the control and the other groups of our study ($P < 0.05$).

Discussion

Since tooth hypersensitivity is a common and annoying disorder in the oral cavity, it is always necessary to create new treatment approaches and materials to degrade its symptoms.⁴ Sensodyne Repair and Protect toothpaste, Gluma gel, and the 810 nm wavelength diode laser are among the therapeutic procedures for tubular closure, whose efficacy in closing the tubules was investigated in this study. According to our findings, it can be concluded that the closing rate of tubules in the 810 nm wavelength laser group ($83 \pm 9.2\%$), Gluma group ($74.4 \pm 11.6\%$), and Sensodyne group ($67 \pm 18.1\%$), in comparison to the control group ($15.03 \pm 3.39\%$), showed the effectiveness of all the groups. The laser had the highest rate of effectiveness. There was a significant difference between the treatment and the control group ($P < 0.05$), while the difference between the Gluma, the 810 nm diode laser, and the Sensodyne groups was not meaningful ($P > 0.05$). Our report shows the ability of all three treatment methods in tubular closure. Kara et al¹⁷ identified that on average, the growth rate in tooth hypersensitivity is more visible in younger individuals and less visible in older populations due to the tubule diameter reduction by the aging process. Therefore, the current study used extracted teeth due to orthodontics treatment plans in patients aged 12 to 25.⁵ This study revealed that the 0.5 W power with an 810 nm wavelength was more effective in closing tubules than the two other methods, but the difference was not significant. The structural changes in the dentin (with the 810 nm laser being irradiated tangentially) can be seen by a SEM microscope (which is affected by laser power and frequency).^{8,13} In a report directed by Saluja et al,⁵ who examined the efficacy of a diode laser on the closure of the tubules, a low-power 810 nm diode laser was used continuously for 30 seconds, and the degree of tubular closure was meaningfully higher than in the control group, as was the case in our study. One of the effects of lasers on the closure of dentinal tubules is the melting of peritubular and inter-tubular dentin, which sometimes even causes the tubules to disappear.⁵ Femiano et al¹¹ claim that the influence of high-power lasers is caused by a thermo-mechanical pathway that results from the high absorption of their wavelength by water. In other words, the blocking effect of the laser is because of the thermal coagulation of the proteins of the tubular liquid, the reduction of the permeability of the tubules, and the blocking of their openings. Jain et al¹⁸ conducted a study showing that low-

level lasers had anti-inflammatory effects on teeth, while high-level ones had damaging effects on pulp. In a study conducted by Rizzante et al,¹⁹ results showed that high-power lasers melted the dentin, and during the process of rehardening, the dentin became a shiny surface without any holes and irregular with a mosaic shape in comparison to open and dilated tubules in the control group, which is consistent with our findings. Aldelaimi et al²⁰ revealed that diode lasers with a wavelength range of 800-980 nm had little absorption in hydroxyapatite and water. The low absorption of the laser by the dentin leads to a gradual thermal increase in the temperature of the dentinal surface. Increasing temperature leads to denaturation and changes in the organic matrix of the dentin to an amorphous and shapeless pattern, and as a result, the tubules are closed by low-power lasers. SEM analysis has shown that the greater the laser power, the higher the effect on the dentinal surface because of the increase in the absorbed energy (irreversible destruction was detected on the tubular surfaces in the laser with a power of 3 W). High-level lasers cause the matrix to melt and re-crystallize on the surface of the dentin, while the mechanism of low-level lasers is more thorough a direct effect on nerve endings, changing nerve transmission, and affecting biostimulation. The increased production of mitochondrial ATP develops the threshold of the free nerve endings and provides a pain-relieving effect due to a surge in b-endorphin in the cephalorachidian liquid.²¹ The decrease in pain occurs due to the inhibition of cyclooxygenase enzyme, which tests the transformation of the arachidonic acid to prostaglandins. The laser also increases the formation of the secondary dentin in through biostimulation.¹⁷ Corona et al¹⁰ identified that if therapy with a laser is used with the correct parameters, it can encourage physiological cell functions. Lasers can motivate tertiary dentin production by increasing odontoblast metabolic actions and obliterating dentinal tubules.¹⁵ In this article, we used a laser in an 810 nm wavelength with a power of 0.5 W (low-level laser), which was effective in closing dentinal tubules, and its outcomes in terms of the mean percentage of dentinal tubule closure were greater than the two other substances (Gluma and Sensodyne), but the difference was not meaningful ($P > 0.05$). Sensodyne Repair and Protect toothpaste contains novamin, an effective ingredient in reducing dentinal hypersensitivity. In Joshi and colleagues' study,¹² the effects of Gluma and novamin on dentinal tubule closure were observed in the study groups in comparison to the control group. In the study conducted by Reddy et al,¹⁴ toothpaste containing pro-argin and novamin had a significant effect on the closure of dentinal tubules. In their study, toothpaste could close dentinal tubules after seven days of daily brushing. Novamin, a newly known substance, has been shown to act as a desensitizing agent by blocking dentinal tubules. Novamin is a type of

bioactive glass-ceramic material that can affect the reaction of calcium and phosphate. The active ingredient in the preparation of novamin is calcium sodium phosphosilicate, and when it is placed in an aqueous medium, calcium and phosphate ions are released, producing hydroxy carbonate apatite (HCA) over time. The combination of novamin and HCA causes the physical closure of dentinal tubules and reduces sensitivity.^{9,11} Furthermore, these types of toothpaste contain sodium ions, and studies have shown that the concentration of sodium ions in the extracellular fluid above physiological limits can make nerve polarity. Sodium ions can also inhibit the action potential in the nerves inside the tooth.^{9,11} The rate of dentinal tubule closure by Gluma was less than that of the laser and more than that of toothpaste, but this difference was not considerable ($P > 0.05$). Kara et al¹⁷ detected that in a group treated by Gluma, numerous transverse septa were created in the tubules in contact with their walls with a depth of 200 μm , and they decided that transverse septa can affect the movement of tubular fluid. In a study by Femiano et al,¹¹ the impact of Gluma on tubular closure was observed. Gluma has 35% hydroxyethyl methacrylate (HEMA) and 5% glutaraldehyde, which coagulate serum albumin in dentinal liquid, and the reaction between glutaraldehyde and albumin causes the polymerization of HEMA. HEMA raises the infiltration of glutaraldehyde into the tubules. Glutaraldehyde causes tubules to close by amino acids denaturing in the tubular fluid. HEMA reduces sensitivity by closing dentinal tubules. In studies directed by Aldelaimi et al²⁰ and Reddy et al,¹⁴ a SEM microscope was used with a 5000 magnification to count tubules with greater clarity. For this reason, we also used the same magnification to count open, semi-closed, and closed tubules. Qualitative inspections of the tubules in the present study showed that tubules were almost open and dilated in the control group. In the laser group, most of the tubules were completely closed and in the Gluma group, semi-closed dentinal tubules were observed in most of the samples. In several studies, various techniques and materials showed different effects on the quality of dentinal tubule closure. In a report conducted by Joshi et al,¹² completely closed tubules were observed in the novamin group, while in the group treated with Gluma, dentinal tubules were observed in semi-closed forms. Patil et al¹⁶ showed that in the images prepared from the samples treated with a laser, the number of closed dentinal tubules was greater than that of semi-closed tubules. In our experiment, based on the images observed under the SEM microscope, the laser caused tubular surface destruction, but other elements only blocked the tubules and left a softer and more gentle surface than the laser, preserving the structure of the tubules. The effect of the laser on the surface can be recognized by the creation of the amorphous form caused by denaturing and changing

the shape of the organic matrix, while Gluma and Sensodyne only cause mechanical obstruction of the tubules.^{8,11} If a specific part of the tooth surface that has been treated with a laser due to sensitivity needs to be filled with filling materials, this treatment will face problems due to closed dentinal tubules, the lack of resin penetration, and the creation of resin tags. Finally, according to our study, it is concluded that all treatment methods have a more considerable effect on the closure of the dentinal tubules than the control group, which can also reduce dental hypersensitivity in patients. Since the efficacy of anti-allergic materials in nerve depolarization should be investigated in the treatment of dental hypersensitivities, further studies are suggested for the clinical assessment of dental hypersensitivity.

Conclusion

In our study, all three treatment methods worked effectively in closing dentinal tubules and could help with reducing hypersensitivity. Due to the structure of the teeth, the process of vacuuming the teeth, which was one of the preparation steps for mounting in the microscope, was very difficult and time-consuming. This is the only part that could be considered as a limitation of the study.

Authors' Contribution

Conceptualization: Arash Azizi, Shirin Lawaf.

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Formal analysis: Arash Azizi, Shirin Lawaf.

Investigation: Parto Nasrollahi.

Methodology: Arash Azizi, Shirin Lawaf, Parto Nasrollahi.

Project administration: Arash Azizi, Shirin Lawaf.

Resources: Seyedeh Saba Sharifzadeh, Parto Nasrollahi.

Software: Arash Azizi, Seyedeh Saba Sharifzadeh.

Supervision: Shirin Lawaf.

Validation: Shirin Lawaf, Arash Azizi.

Visualization: Shirin Lawaf, Arash Azizi.

Writing—original draft: Seyedeh Saba Sharifzadeh.

Writing—review & editing: Seyedeh Saba Sharifzadeh, Shirin Lawaf.

Competing Interests

None declared.

Ethical Approval

In this study, 40 premolar teeth were selected from newly extracted teeth in people aged 12 to 25 for orthodontic purposes. Teeth with decay, restoration, root treatment, fracture, wear, or dental anomalies were excluded from the study. The present study was conducted in the Faculty of Pharmacy and Pharmaceutical Sciences, Islamic Azad University of Medical Sciences, Tehran, Iran, and it was approved under the ethics code ID IR.IAU.PS.REC.1398.050.

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References

1. Naghsh N, Hosseini A, Bazmara A, Birang R. Evaluation of three methods for the treatment of dentin hypersensitivity: a randomised clinical trial. *Int Dent J*. 2024. doi: [10.1016/j.identj.2024.03.013](https://doi.org/10.1016/j.identj.2024.03.013).
2. Johnson RH, Zulqar-Nain BJ, Koval JJ. The effectiveness of

- an electro-ionizing toothbrush in the control of dentinal hypersensitivity. *J Periodontol.* 1982;53(6):353-9. doi: [10.1902/jop.1982.53.6.353](https://doi.org/10.1902/jop.1982.53.6.353).
3. Kunam D, Manimaran S, Sampath V, Sekar M. Evaluation of dentinal tubule occlusion and depth of penetration of nano-hydroxyapatite derived from chicken eggshell powder with and without addition of sodium fluoride: an in vitro study. *J Conserv Dent.* 2016;19(3):239-44. doi: [10.4103/0972-0707.181940](https://doi.org/10.4103/0972-0707.181940).
 4. Cattoni F, Ferrante L, Mandile S, Tetè G, Polizzi EM, Gastaldi G. Comparison of lasers and desensitizing agents in dentinal hypersensitivity therapy. *Dent J (Basel).* 2023;11(3):63. doi: [10.3390/dj11030063](https://doi.org/10.3390/dj11030063).
 5. Saluja M, Grover HS, Choudhary P. Comparative morphologic evaluation and occluding effectiveness of Nd:YAG, CO₂ and diode lasers on exposed human dentinal tubules: an in vitro SEM study. *J Clin Diagn Res.* 2016;10(7):ZC66-70. doi: [10.7860/jcdr/2016/18262.8188](https://doi.org/10.7860/jcdr/2016/18262.8188).
 6. Aghayan S, Fallah S, Chiniforush N. Comparative efficacy of diode, Nd:YAG and Er:YAG lasers accompanied by fluoride in dentinal tubule obstruction. *J Lasers Med Sci.* 2021;12:e63. doi: [10.34172/jlms.2021.63](https://doi.org/10.34172/jlms.2021.63).
 7. Yilmaz NA, Ertas E, Orucoğlu H. Evaluation of five different desensitizers: a comparative dentin permeability and SEM investigation in vitro. *Open Dent J.* 2017;11:15-33. doi: [10.2174/1874210601711010015](https://doi.org/10.2174/1874210601711010015).
 8. Khoubrouypak Z, Hasani Tabatabaei M, Chiniforush N, Moradi Z. Evaluation of the effects of 810 nm diode laser alone and in combination with Gluma© and chromophore on dentinal tubule occlusion: a scanning electron microscopic analysis. *J Lasers Med Sci.* 2020;11(3):268-73. doi: [10.34172/jlms.2020.45](https://doi.org/10.34172/jlms.2020.45).
 9. Hoshiyari N, Zamanian A, Samii A, Mousavi J. In-vitro comparison of occluding effect of fluoride varnish and diode laser irradiation with fluoride varnish and Er,Cr:YSGG laser irradiation on dentinal tubules of the cervical root area of the tooth. *Maedica (Bucur).* 2023;18(2):257-65. doi: [10.26574/maedica.2023.18.2.266](https://doi.org/10.26574/maedica.2023.18.2.266).
 10. Corona SA, do Nascimento TN, Catirse AB, Lizarelli RF, Dinelli W, Palma-Dibb RG. Clinical evaluation of low-level laser therapy and fluoride varnish for treating cervical dentinal hypersensitivity. *J Oral Rehabil.* 2003;30(12):1183-9. doi: [10.1111/j.1365-2842.2003.01185.x](https://doi.org/10.1111/j.1365-2842.2003.01185.x).
 11. Femiano F, Femiano R, Lanza A, Festa MV, Rullo R, Perillo L. Efficacy of diode laser in association to sodium fluoride vs Gluma desensitizer on treatment of cervical dentin hypersensitivity. A double blind controlled trial. *Am J Dent.* 2013;26(4):214-8.
 12. Joshi S, Gowda AS, Joshi C. Comparative evaluation of NovaMin desensitizer and Gluma desensitizer on dentinal tubule occlusion: a scanning electron microscopic study. *J Periodontal Implant Sci.* 2013;43(6):269-75. doi: [10.5051/jpis.2013.43.6.269](https://doi.org/10.5051/jpis.2013.43.6.269).
 13. Liu Y, Gao J, Gao Y, Xu S, Zhan X, Wu B. In vitro study of dentin hypersensitivity treated by 980-nm diode laser. *J Lasers Med Sci.* 2013;4(3):111-9.
 14. Reddy GV, Akula S, Malgikar S, Babu PR, Reddy GJ, Josephin JJ. Comparative scanning electron microscope analysis of diode laser and desensitizing toothpastes for evaluation of efficacy of dentinal tubular occlusion. *J Indian Soc Periodontol.* 2017;21(2):102-6. doi: [10.4103/jisp.jisp_153_17](https://doi.org/10.4103/jisp.jisp_153_17).
 15. Jena A, Kala S, Shashirekha G. Comparing the effectiveness of four desensitizing toothpastes on dentinal tubule occlusion: a scanning electron microscope analysis. *J Conserv Dent.* 2017;20(4):269-72. doi: [10.4103/jcd.jcd_34_17](https://doi.org/10.4103/jcd.jcd_34_17).
 16. Patil AR, Varma S, Suragimath G, Abbayya K, Zope SA, Kale V. Comparative evaluation of efficacy of iontophoresis with 0.33% sodium fluoride gel and diode laser alone on occlusion of dentinal tubules. *J Clin Diagn Res.* 2017;11(8):ZC123-6. doi: [10.7860/jcdr/2017/29428.10526](https://doi.org/10.7860/jcdr/2017/29428.10526).
 17. Kara HB, Cakan U, Yilmaz B, Inan Kurugol P. Efficacy of diode laser and Gluma on post-preparation sensitivity: a randomized split-mouth clinical study. *J Esthet Restor Dent.* 2016;28(6):405-11. doi: [10.1111/jerd.12230](https://doi.org/10.1111/jerd.12230).
 18. Jain PR, Naik GD, Uppor SA, Kamath DG. Diode laser and fluoride varnish in the management of dentin hypersensitivity. *J Interdiscip Dent.* 2015;5(2):71-4. doi: [10.4103/2229-5194.173226](https://doi.org/10.4103/2229-5194.173226).
 19. Rizzante FA, Maenosono RM, Palma-Dibb RG, Duarte MA, Ishikiriama SK. Evaluation of dentinal permeability reduction provided by different desensitizing treatments. *RSBO.* 2014;11(3):215-3.
 20. Aldelaimi AA, Aldelaimi TN, Al-Gburi SM. Using of diode laser (940 nm) in orofacial region. *J Res Med Dent Sci.* 2017;5(5):34-9. doi: [10.24896/jrmcs.2017557](https://doi.org/10.24896/jrmcs.2017557).
 21. Pandey R, Koppolu P, Kalakonda B, Lakshmi BV, Mishra A, Reddy PK, et al. Treatment of dentinal hypersensitivity using low-level laser therapy and 5% potassium nitrate: a randomized, controlled, three arm parallel clinical study. *Int J Appl Basic Med Res.* 2017;7(1):63-6. doi: [10.4103/2229-516x.198526](https://doi.org/10.4103/2229-516x.198526).