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# Effects of GLUMA Desensitizer and Low-Level 980 nm Diode Laser on the Retention of the Metal Frames of the PFM Crowns Cemented by Self-adhesive Resin Cement (RelyX U200)

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## Abstract

**Introduction:** Sometimes, dentinal tubules are exposed to the oral cavity during the preparation of vital teeth for crowns, and patients show various signs of tooth hypersensitivity. Some treatments have been suggested for dental hypersensitivity after tooth preparation, such as low-level diode laser (980 nm) and GLUMA desensitizer. The pretreatment of dentin with desensitizers may affect retention. The aim of this study was to ascertain the effects of the 980nm Diode laser and GLUMA Desensitizer on the retention of the metal frames cemented by self-adhesive resin cement (RelyX U200).

**Methods:** Thirty intact permanent maxillary first premolars were used in this study. After preparing teeth with 0.5 to 0.7 finishing line above CEJ, casting full metal crowns with a 5-diameter ring on the occlusal surface was done. Then the samples were divided into 3 groups: (1) Control Group (n = 10), (2) 980 nm diode laser (n = 10), and (3) GLUMA desensitizer (n = 10). Frames were cemented with self-adhesive resin cement (RelyX U200) and the bond strength was measured by universal testing machine. Data were analyzed by ANOVA and Tukey post hoc tests in SPSS version 25 ($P < 0.05$).

**Results:** Frame retention in the 980 nm diode laser group (40.90 ± 27.07N) was significantly lower than the control group (138.17 ± 40.81 N) and the GLUMA desensitizer group (318.59 ± 56.31N) ($P < 0.05$), and frame retention in the GLUMA Desensitizer group was significantly higher than the other groups ($P < 0.05$).

**Conclusion:** The GLUMA desensitizer has a positive effect and the 980 nm diode laser has a negative effect on the retention of frames cemented by self-adhesive resin cement (RelyX U200).

**Keywords:** Retention; GLUMA desensitizer; 980nm diode laser; Metal frame; Resin cement.

## Introduction

A key issue and factor affecting the stability of dental crowns on the prepared teeth is retention.[1] The optimum retention for extra-coronal restorations based on the geometric shape analysis of prepared teeth depends on such factors as convergence of the walls, amount of preparation, roughness of the crown's internal surface, retentive grooves, prepared tooth surface features, and the type of cement used.[2] If the previous factors are not provided properly, complications such as microleakage, secondary caries under the crowns, washed-out cement beneath the crown, and final failure of the crown will occur.[2]

Most patients with fixed restorations on teeth with vital pulp experience discomfort, pain or other uncomfortable symptoms in prepared teeth during the treatment and sometimes after restoration placement which may be due to dentin hypersensitivity.[3] Frictional heat during preparation could also increase dental hypersensitivity.[4] It is reported that millions of dentinal tubules are exposed during tooth preparation of posterior crowns.[5] During the last decades and according to the introduction of newer methods and the prevalence of hypersensitivity after cementation, the widespread use of desensitizing drugs has occurred.[3] Treatment options for tooth hypersensitivity include treatments that are done at home by either an individual or by a specialist in the office.[6] These treatments include the sealing of dentinal tubules through calcium phosphate deposition,[5] the effect of Potassium Nitrate on nerve impulses,[6] the sealing of dentinal tubules through protein deposition,[7] the photobiomodulation therapy with lasers that can cause the depolarization of nerve fibers and the formation of tertiary dentin, and the use of high-power lasers that can cause the sealing of dentinal tubules through

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the recrystallization of the dentin's mineral components.[8] Also, resin adhesives, which act as a biological sealer by infiltrating the exposed dentinal tubules and creating a hybrid layer by hybrid resin tags, reduce the permeability of the dentinal tubules.[5] In 2023, Mancuso et al reported that applying GLUMA desensitizers to dentin before utilizing two universal adhesives in the self-etch mode may enhance the bond strength instantaneously. [9]

In 2012, Jalandar et al[10] reported that the GLUMA Desensitizer does not influence the retention of crowns.[10] Yim et al reported that GLUMA reduces the retention of crowns cemented by resin cements.[11] Kumar et al concluded that the Er,Cr:YSGG laser does not influence the retention of metal crowns that have been cemented using resin cement.[12] In 2017, Gupta et al stated that a 980 nm diode laser reduces mean shear bond strength.[13]

According to existing contradictions and limitations of previous research studies and the existing gap in knowledge, this research aimed to ascertain the effects of GLUMA desensitizer and low-level 980 nm diode laser on the retention of metal frameworks of the porcelain fused to metal (PFM) dental crowns which were cemented by self-adhesive resin cement (RelyX U200).

## Materials and Methods

According to previous studies and using PASS 11 software with $\alpha = 0.05$ and $\beta = 0.2$ and an average standard deviation of 51.00 N and an effect size of 0.61, the minimum sample size needed for each of the three groups was 10.[14] Thus, a total of 30 intact, virtually equal in size, maxillary first permanent premolars[12,14] extracted for orthodontic reasons were collected and used for the study. The teeth were placed in a 0.1% Thymol solution for a duration of 48 hours to ensure disinfection, and the remaining tissues around the roots were removed.[14-16] Then the teeth were prepared by utilizing a Milling machine (Milling machine, Degussa; Germany) toward the vertical axis of the tooth with a Survey (Paraline, Dentaurum; Germany).[12,14,17] For this purpose, the teeth were positioned on molds made of dental stone (Ariadent, Tehran, Iran) and inserted into the milling machine. A round end tapered diamond bur (Dia-burs, Mani Inc; Japan) was used for occlusal reduction.[14] A chamfer finishing line with 0.5-0.7mm depths above CEJ was prepared using a torpedo bur (Dia-burs, Mani Inc; Japan) (Figure 1A).[12,18] A 4 mm axial height and 6 degrees taper was considered for the preparation of all samples.[10,14] The teeth were finished with a round-end taper fine grit diamond bur (Dia-burs, Mani Inc; Japan), and subsequently, all line angles were rounded using abrasive strips (Ceramill Map 400, Amann Girrbach; Germany). Wax patterns featuring a thickness of 0.5 mm and a spacer of 30 µm were meticulously designed for each sample using software (Dental CAD, Exocad; Germany) (Figure 1B), and wax blocks were carved using a CAD/CAM machine (CeramiII motion 2, Amann Girbach; Germany).[17] Subsequently, a ring with an internal diameter of 5mm was designed on the occlusal surface of wax patterns. This ring, later cast on the metal frame, was used for jig attachment for conducting retention testing in a universal machine (Zwick Z050; Roell Group, Ulm, Germany) (Figure 1C).[14,17] The wax patterns (Machinable Wax Block Milling for Dental CAD/CAM System 98*10 mm Casting, Shenzhen; China) were then invested in high-strength phosphate investment stone (Wirovest, Bego Corp; Germany), and metal frames were created through the investment casting process. [14] Afterward, the cast metal frames were carefully positioned on the teeth, and the fit-checker (GC Corporation, Tokyo, Japan), explorer and magnifier were used to verify marginal integrity and proper seating.[12,14] In order for us to reach the most similar and best fitness of the frames and to get rid of the small particles left after casting and investment, finishing needed to be done. Metal frames were then finished by metal finishing stones and burs and sandblasted using 50µ aluminum oxide particles (3-Kammer-Sandstrahler Typ TopStar z 3, Bego; Germany).[12,14] They were subjected to cleaning in an ultrasonic bath (USG 4000 Ultraschall, Dentaurum; Germany) for a duration of 60 seconds afterward.[14] The teeth were randomly divided into two experimental groups and one control group. In the first group, the GLUMA Desensitizer (GLUMA Desensitizer, Heraeus Kulzer; Germany) which is a combination of glutaraldehyde 5% and hydroxyethyl methacrylate (HEMA) 35% was applied to the surfaces of ten teeth using a microbrush, and it was left in place for 60 seconds as per the manufacturer's instructions. Compressed

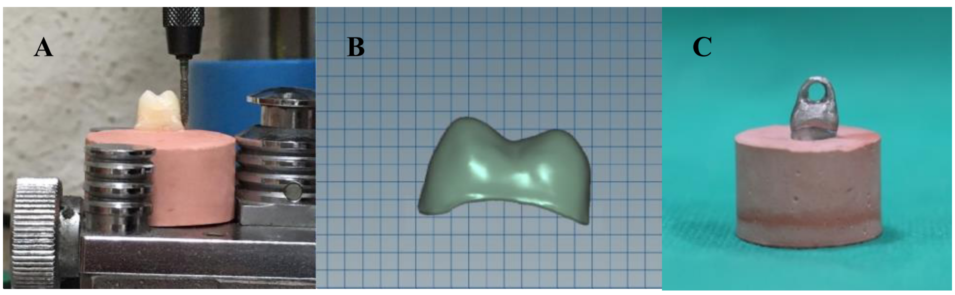


**Figure 1**. The Application of GLUMA**. A.** Finishing line preparation using a torpedo bur. **B**. Wax patterns were designed using Exocad software. **C**. The ring, cast on a metal frame, was used for jig attachment for retention testing in a universal machine.

air was sprayed until the liquid disappeared and the surface was no longer glistening. The teeth were rinsed completely with water afterward.[14] In the second group, the 980 nm laser (Simpler, Doctor Smile; Italy) with a handpiece with a diameter of 1cm and an energy density of 9.55 J/cm$^2$, in a sweeping motion, was irradiated on 10 teeth with 0.5 W/CW power for 15 seconds, 3 times without contact, every 24 hours with continuous mode, perpendicular to the tooth surface.[19] Finally, no treatment was done for 10 remaining teeth. In order to achieve an equal thickness of the resin cement (RelyX U200, 3M; USA) in all samples, the cement was mixed with factory instructions.[20] The cemented crowns were seated on the teeth with finger pressure.[14] After that, a 5-kg constant axial load was applied over each frame for 10 minutes.[14, 21] After 2 minutes, additional cement was removed with an explorer. In order to make sure that the cement was cured, the frames' margins were cured by a light cure unit with a light intensity of 850 mW/cm$^2$ (LED.D, Woodpecker; China) perpendicularly for 20 seconds with a 0.5 cm distance.[17] Next, the samples were kept in an incubator (Kavosh, Mega; Iran) at 37 °C for 24 hours.[14] After that, the teeth were extracted from the stone and grooves were put on their roots in order to remain in acryl. Subsequently, the samples were mounted inside 25*25*30 mm metal blocks perpendicularly and 2 mm under CEJ inside self-cure acryl (Cold-cure Acryl, Acropars; Iran).[14,22] Eventually, a retention test was performed using a universal testing machine (Z050, Zwick/Roell; Germany), along with a custom-designed metal jig connected to the upper section of the device, with a crosshead speed set at 0.5 mm/min as advised by ADA standards for cement evaluation.[14,22] When the frames were separated from the prepared teeth, the debonded surfaces were evaluated using a stereomicroscope (SMZ800, Nikon; Japan) with × 30 magnification to ascertain the mode of failure, which was categorized into 3 groups[14,22]:

1. Cohesive failure: More than 75% of bonded cement remained on the tooth surface.
2. Adhesive failure: Less than 25% of bonded cement remained on the tooth surface.
3. Mixed failure: Between 25% to 75% of bonded cement remained on the tooth surface.[14]

At the end of the study, the obtained retention values in three experimental groups were analyzed using ANOVA, Kolmogorov-Smirnov and post hoc tests (Tukey test) in two independent populations using SPSS version 25 software. A $P$ value less than 0.05 was considered statistically significant.

## Results

The retention of the frame was 138.17 ± 40.81 N in the control group, 40.90 ± 27.07 N in the 980 nm diode laser group, and 318.59 ± 56.31 N in the GLUMA group (Figure 2).

The results of the Kolmogorov-Smirnov test about the frame retention rate in the three groups follow a normal distribution ($P = 0.2$). The results of the one-way ANOVA test regarding the frame retention of all three study groups have significant differences in the rate of retention ($P < 0.01$). The frame retention and the results of the post hoc Tukey test in the two independent communities for the retention in the three groups are indicated in Table 1.

The mode of failure in the control group was adhesive in four samples, combined in five samples, and cohesive in one sample; in fact, in this group, the failure tended to be adhesive. In the GLUMA group, the fractures were cohesive in six samples and mixed in four samples, and in this group, the fractures tended to be cohesive. Also, in the 980 nm diode laser group, the failure was combined in five samples and adhesive in five samples, and in this group, the fracture tended to be adhesive.

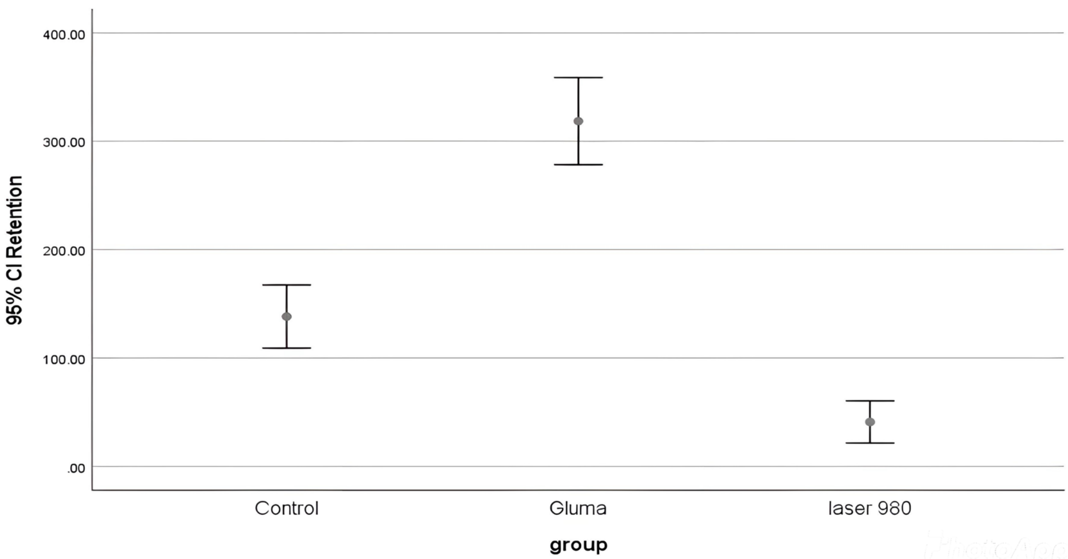


**Figure 2.** Frame Retention in Three Study Groups

**Table 1.** Tukey Post Hoc Test Results of the Retention Rate in Three Study Groups

| Group 1 | | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| Control | GLUMA | -180.41800 | 19.27116 | 0.000 | -228.1993 | -132.6367 |
| | laser 980 | 97.26900 | 19.27116 | 0.000 | 49.4877 | 145.0503 |
| GLUMA | Control | 180.41800 | 19.27116 | 0.000 | 132.6367 | 228.1993 |
| | laser 980 | 277.68700 | 19.27116 | 0.000 | 229.9057 | 325.4683 |
| laser 980 | Control | -97.26900 | 19.27116 | 0.000 | -145.0503 | -49.4877 |
| | GLUMA | -277.68700 | 19.27116 | 0.000 | -325.4683 | -229.9057 |

## Discussion

Most of the patients with fixed restorations on teeth with vital pulp experience discomfort in prepared teeth during the treatment and sometimes after restoration placement which may be due to dentin hypersensitivity.[3] GLUMA desensitizer and photobiomodulation therapy with a 980nm diode laser are two desensitizing treatments for overcoming this problem.[7]

Hence, considering that these treatments cause changes in the surface properties of teeth and also given the importance of cement bond strength in the efficacy of prosthetic treatments, a query has been raised regarding the impact of GLUMA and a 980 nm diode laser on the retention of metal frameworks cemented with self-adhesive resin cement (RelyXU200). The results of this experimental study demonstrated that the retention in the GLUMA group was significantly higher than in the 980 nm laser group and the control. Additionally, the retention in the 980 nm laser group was significantly lower than in the other two groups. Therefore, considering the constraints of this study, we rejected our null hypothesis, which stated that there would be no differences in the metal framework retention rates between the GLUMA, low-level 980 nm, and control groups that were cemented using self-adhesive resin cement (RelyX U200).

The bond strength of self-adhesive resin cements depends on diverse factors such as the type of dentin, the depth of preparation and the surface of the tooth. Adhesion of self-adhesive resin cements to dentin and some restorative materials is acceptable, while adhesion to enamel is poor based on their bonding characteristics.[23] These cements are distinguished by the presence of hydrophilic acid monomers that effectively adhere to the wet dentin surface.[3] Their capacity to bond to the tooth structure depends on the infiltration of the monomer into the tissue and the subsequent formation of the resin-infiltrated layer, which is also influenced by the presence of hydroxyapatite necessary for establishing a bond with the tooth structure.[23]

According to Gaffar study,[24] RelyX U200 cement has acidic monomers that cause demineralization and tooth infiltration, resulting in micromechanical retention and secondary chemical bonding with hydroxyapatite. The distinctive feature of this cement is the new modified lubricant that has reduced its viscosity and is presumably the reason for the superior bond strength of this cement compared to other cements since using this lubricant results in better infiltration into the smear layer and better wetting of the dentin.

In the past few years, numerous studies have examined how desensitizers affect the bonding of dentin to various cements, including studies by Mancuso et al in 2023,[9] Elizalde-Hernández et al in 2022,[23] Gupta et al in 2017,[25] Lawaf et al in 2016,[14] and Acar et al in 2014.[22]

Regardless of the type of cement and the type of desensitizer used, there are limited studies that have utilized the methodology presented in this study, including studies conducted by Lawaf et al in 2016,[14] Acar et al in 2014,[22] and Jalandar et al in 2012.[10]

GLUMA desensitizer consists of glutaraldehyde and HEMA. Glutaraldehyde acts by coagulating amino acids and proteins within dentinal tubules and serves as a potent antiseptic. HEMA effectively occludes dentinal tubules.

Qin et al[26] in 2006 reported that glutaraldehyde in HEMA could not crosslink with mineralized dentin. There have been reports indicating that desensitizing agents containing glutaraldehyde and HEMA contribute to the creation of a collagen-glutaraldehyde layer at the junction of the desensitizing agent and the dentin. A chemical bond is formed between the HEMA found in the desensitizing agent and the collagen-glutaraldehyde complex.[26] Polymerization between the HEMA complex and resin cement, along with the rewetting properties of HEMA, the buffering capacity of resins, and the micro-mechanical bonding established between protein plugs formed by GLUMA and resin tags, may contribute to the enhanced retention rates observed when resin cements are used in conjunction with GLUMA.[5] In 2022, Dewan et al[3] stated that HEMA in GLUMA increases the dentin wettability by the resin cement, which helps to increase the bond strength.

Sayed[5] in a systematic review in 2023 reported that the use of GLUMA effectively occludes the majority of dentinal tubules and infiltrates them as plugs while maintaining the surface irregularities of the dentin. Consequently, it does not compromise the retention of cemented crowns.

Another desensitizing treatment used in the present study is a 980 nm diode laser. In this study, the effect of the 980 nm diode laser on the bond strength of self-adhesive resin cement, RelyX U200, was investigated.

In 2005, Sipahi et al[27] stated that laser beams cause the evaporation of the water inside the dentinal tubules. This increase in volume causes microexplosion inside the dentinal tubules, which causes cracks in their walls. The sealing of dentinal tubules occurs due to the explosion and its products.

Wang et al,[28] in 2005, stated that a diode laser has very good absorption in melanin and hemoglobin, and it is also absorbed in water and hydroxyapatite to a small extent, and this low absorption can cause a change in the morphology of the dentine surface.

Corona et al[29] stated that a low-level laser can stimulate the production of sclerotic dentine, and as a result, the occlusion of dentinal tubules occurs. According to this study, odontoblast stimulation, production of tertiary dentine and occlusion of dentinal tubules happen due to laser irradiation.

In the present study, the result of using a 980 nm laser with a power of 0.5 W/CW was a significant decline in the bond strength of the self-adhesive resin cement in metal frames. The reason for this decline is probably due to the sealing of dentinal tubules.

Considering the effect of pre-treatments such as GLUMA on the morphologic features of the dentin surface, these desensitizing agents can be highly effective in retention. In the present study, the results demonstrated that GLUMA had a positive effect on the retention of metal frames of the PFM crowns cemented by self-adhesive RelyX U200 cement. However, the retention in the 980 nm diode laser group was significantly lower than the control and GLUMA groups. In some examples, due to the shortness of the teeth or improper geometry of preparation, there is a possibility of reducing the retention of the metal frames of the PFM crowns. In these cases, desensitizing treatment is suggested, considering that the simultaneous application of GLUMA and self-adhesive resin cement enhances retention.

## Conclusion

According to the limitations of this study and its methodology, the positive effect of GLUMA Desensitizer on the retention of the metal frames of the PFM crowns cemented by self-adhesive RelyX U200 cement was confirmed. In the current study, the negative effect of the 980nm diode laser on the retention of the metal frames of the PFM crowns cemented by self-adhesive RelyX U200 cement was approved as well.

### Authors' Contribution

**Conceptualization:** Mohammad Joudaki.
**Data curation:** Arash Azizi.
**Formal analysis:** Shirin Lawaf.
**Investigation:** Arash Azizi.
**Methodology:** Shirin Lawaf.
**Project administration:** Shirin Lawaf.
**Resources:** Arash Azizi.
**Software:** Shirin Lawaf.
**Supervision:** Shirin Lawaf.
**Validation:** Shirin Lawaf.
**Visualization:** Shirin Lawaf.
**Writing–original draft:** Mohammad Joudaki.
**Writing–review & editing:** Sahel Bazarnoei.

### Competing Interests

The authors assert that they have no known competing financial interests or personal connections that might have appeared to influence the work reported in this paper.

### Ethical Approval

This study has been approved by the Islamic Azad University, Dental Branch of Tehran. (Ethics code No. IR.IAU.DENTAL.REC.1397.031)

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