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Effect of Silver Diamine Fluoride and Diode Laser as Desensitizer on The Microleakage and Discoloration at Class V Restorations

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ABSTRACT

Aim: The aim of this study was to evaluate the effects of silver diamine fluoride and diode laser applications used for desensitization on microleakage and colour change in the restorations of class V cavities.

Materials and Methods: Twenty human molar teeth were used in this study. ClassV cavities (4x3x3 mm) (n=10) were prepared on the buccal and lingual surfaces. All teeth were divided into 4 groups according to the treatment methods for DH. Group 1 (silver diamine fluoride), Group 2 (940 nm diode laser), Group 3 (940 nm diode laser + silver diamine flouride), Group 4 (no treatment). All cavities were restored with nano-hybrid composite resin. Restorations were polished with discs. Colour changes were measured with a spectrophotometer on 1, 7, 14, 28 days. Colour change was calculated with the CIEDE2000 formula. To evaluate microleakage scores, samples were stained with 0.2% RhodamineB dye and cut bucco-lingually. Dye penetration was scored under a stereomicroscope. Data were statistically analyzed using the Shapiro-Wilks and Tukey HSD test at a 5% significance level.

Results: According to the colour changes, a statistically significant difference was found between Group 1 and Group 3. In Group 2, there was significantly difference between 1-7 and 1-14 days, 1-7 and 1-28 days. The highest microleakage scores were obtained with the laser-used groups.

Conclusion: Despite the use of a solution containing potassium, a colour change above the clinically acceptable threshold was observed in silver diamine used groups. Also, laser used groups have shown unacceptable colour change values.

Sınıf V Kompozit Restorasyonlarda Hassasiyet Giderici Olarak Kullanılan Gümüş Diyamin Florür ve Diyot Lazerin Mikrosızıntı ve Renk Değişmesi Üzerindeki Etkisi

Makale Bilgisi

Makale Geçmişi

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Diyot,
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Gümüş diamin florür.

ÖZET

Amaç: Bu çalışmanın amacı, hassasiyet giderici amaçlı kullanılan gümüş diamin florür ve diyot lazer uygulamalarının sınıf V kavitelerin restorasyonlarında, mikrosızıntıya ve renk değişimine olan etkilerini değerlendirmektir.

Gereç ve Yöntemler: Bu çalışmada yirmi adet insan molar dişi kullanıldı. Her bir dişin bukkal ve lingual yüzeylerinde standart Sınıf V kaviteler (4x3x3mm) hazırlandı. Dişler tedavi yöntemlerine göre rastgele 4 gruba (n=10) ayrıldı. Grup 1(gümüş diamin florür), Grup 2 (940 nm diyot lazer), Grup 3 (gümüş diamin florür + 940 nm diyot lazer), Grup 4'teki örneklere hiçbir tedavi protokolü uygulanmadı. Tüm kaviteler, nano-hibrid kompozit rezin ile restore edildi. Restorasyonlar diskler ile cilalandı. Örneklerin renk ölçümü spektrometre cihazı ile 1, 7, 14, ve 28. günlerde yapıldı. Renk değişimi, CIEDE 2000 formülüyle hesaplandı. Örnekler %0.2 Rhodamine B boyası ile boyandı ve bukko-lingual yönde kesildi. Boya penetrasyonu bir stereomikroskop altında skorlandı. Veriler Shapiro-Wilks ve Tukey HSD testi kullanılarak %5 anlamlılık düzeyinde istatistiksel olarak analiz edildi.

Bulgular: Renk değişimi açısından değerlendirildiğinde, Grup 1 ve Grup 3 arasında istatistiksel olarak anlamlı bir fark bulundu. Grup 2'de, 1-7. gün ile 1-14. Gün, 1-7. gün ile 1-28. Gün zaman aralıklarında, renk değişimi farkı istatistiksel olarak anlamlı bulundu. En yüksek mikrosızıntı skorları, lazer kullanılan gruplarda elde edilmiştir.

Sonuç: Potasyum içeren solüsyonun kullanılmasına rağmen gümüş diamine florür uygulanan gruplarda renk değişimi eşik değerin üzerinde görüldü. Ayrıca, lazer kullanılan gruplarda da kabul edilemez renk değişimleri gözlendi.

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INTRODUCTION

Dentists are still researching for ideal treatments to overcome dentin hypersensitivity (DH) problems in the cervical area of the teeth.[1] Patients complain of sharp pain, especially as a result of stimuli such as hot, cold, acidic drinks, sweeteners, and chemical agents.[2] DH prevalence is reported between 3 and 57 % in adults.[3] Exposure to dentin in the cervical area can be caused by many factors such as abrasion, attrition, erosion, brushing, and periodontal disease.[4] In 1962, Brannstorm explained the DH with hydrodynamic theory. According to the hydrodynamic theory, the movement of dentinal fluid can cause DH.[5]

Several treatment options for DH have been performed in practice. Although the use of desensitizing gels, solutions, and pastes is more common for the treatment of DH, the use of laser for desensitizing purposes has also become popular.[6,7] The positive effects of laser on DH were reported in some studies.[8,9] Nd: YAG, Er: YAG, CO_2, and Ga-Al-As (diode) lasers are preferred due to the reduction of DH. Researchers and clinicians may prefer lasers in some cases because of the analgesic and anti-inflammatory properties of lasers [8.]The mechanism of laser on dentin tubules for reducing DH depends on the laser type and application parameters.[10]

The effects of lasers on DH can be explained by obstruction of dentinal tubules.[10] On the other hand, it was mentioned that lasers affect the movement of dentinal fluid.[10] It was stated that this type of laser decreases the DH by blocking the depolarization of C-fiber.[12] It was shown that a 940 nm diode laser was effective on DH after flap surgery.[13] Also, in a study on DH, it was found that the application of a 795-nm diode laser decreased DH in a 6-month follow-up period.[14]

Recently, new agents have been applied to treat DH as an alternative to conventional agents. Silver diamine fluoride (SDF) is one of them.[15] Firstly, SDF was introduced in 1969 to arrest carious lesions.[16,17] In the literature, the use of 38% SDF is the most effective concentration in preventing caries. [15,17] SDF has also played role on reducing DH by plugging of dentinal tubules. It was claimed that the insoluble silver iodide precipitate, occluding dentinal tubules, providing immediate sensitivity relief.[18] Riva Star Aqua (RSA) (SDI, Bayswater, Victoria, Australia) is the new non-invasive system to prevent carious lesions and desensitize.[15] RSA can be also used in the same indications with SDF 38%. RSA is a water-based solution without ammonia. The discolouration is the most known side effect of SDF. [15] It was reported that potassium iodide (KI) reduces discolouration.[19] Therefore, the use of KI after SDF can be an option for reducing discolouration.[15, 20] RSA has two different colour capsules. While the silver blue capsule is water-based SDF, the green capsule in the second step is used to prevent discolouration with KI.Researchers stated that it is the best option to use of laser and cover of exposed dentin surface with restorative materials for the treatment of non-carious cervical lesions (NCCL). [21, 22]

Microleakage is one of the most important factors affecting the long-term success of restorations. Microleakage can cause marginal discolouration, post-operative sensitivity, secondary caries, and damage of pulp.[23] Especially, in Class V cavities, microleakage is a problem because it is located below to cemento-enamel junction.[24,25] Although SDF and diode laser are known to reduce DH, there is no study in the literature comparing the microleakage and effects on the composite discolouration of SDF-containing agent and diode laser.

In general, cervical lesions and hypersensitive dentin are observed together in clinical situations.[21] In such cases, restorative treatment is needed to overcome DH and cover cervical lesions after desensitizing procedures.[21]

Therefore, the aim of this study was to compare the effect of using SDF and laser on the colour change (ΔE) and microleakage values in class V resin restorations. The null hypotheses of the study are: 1-) There would be

no significant difference between the ΔE values in groups in which SDF is used 2-) There would be no significant difference between the microleakage scores in groups between laser used and SDF used.

METHODS

This study was approved by Ethical Committee of Okan University.

Tooth Selection

Using the "G*Power statistical program (ver. 3.1.9.4; Foul and Erdfelder, 1998)"; When the Type-1 error is 5%, the effect size is 0.2, and the power is 95%, the sample size is at least 10 cavities per group were found.[26] Thus, a total of 20 non-carious, non-erupted, non-functional human permanent third molars were used in this study. All teeth were scaled with scaling instruments to remove residual tissues and stored in distilled water at room temperature until used in the experiments.

Tooth Preparation

All procedures were performed by single experienced researcher. Standard Class V cavities (4 mm width, 3 mm high, 3 mm depth) were prepared on both the buccal and lingual surfaces of each tooth. Thus, 40 cavities were obtained from 20 teeth. Then each group was divided into four groups depending on the desensitization method.

Treatment and Restoration Procedures:

Group 1: RSA (SDI, Bayswater, Victoria, Australia) was applied using a micro-brush 10 s first with the silver blue capsule. Secondly, the green capsule was applied until the creamy white precipitate turned clear. The cavities were rinsed with water and dried then were etched with 37,5% phosphoric acid for 15 s, rinsed with water and dried. A self-etch bonding agent (Tokuyama Bond Force II, Tokuyama Dental, Tokyo, Japan) was applied and light-cured for 20 s. Supra-nanohybrid composite (Tokuyama Estelite Sigma Quick, Tokuyama Dental, Tokyo, Japan) was applied incrementally and cured 20s.

Group 2: The cavities were irradiated by the 940-nm diode laser (Biolase, CA, USA) with a power of 1 W for 60 s. Then, as in Group 1, the same acid-etch, bonding and restoration procedures were applied.

Group 3: The cavities were irradiated by the 940-nm diode laser (Biolase, CA, USA) with a power of 1 W for 60 s. RSA application procedures were repeated. Then, like the other groups, the same acid-etch, bonding and composite application procedures were applied.

Group 4 (control): No treatment was applied. The same acid etch-bonding and composite application procedures were applied.

For all groups, soflex discs (3M ESPE, St. Paul, MN, U.S.A.) were used for finishing and polishing.The materials used were shown in Table 1.

Table 1. The materials used in this study

Type of Materials	Manufacturers	Compositions
Supra nano-hybrid composite resin	Tokuyama Estelite Sigma Quick, Tokuyama Dental Corporation, Tokyo, Japan	Bis-GMA, UDMA, TEGDMA, Silica-zirconia monodispersing spherical (71% by vol.,82% by weight)
Silver diamine fluoride	Riva Star Aqua, SDI, Bayswater, Victoria, Australia	Silver, fluoride,ammonium hydroxide, potassium iodide and water
Tokuyama bond force II	Tokuyama Dental Corporation, Tokuyama Dental, Tokyo, Japan	Phosphoric acid monomer, Bis-GMA, TEGDMA, HEMA, Alcohol, Water, Camhorquinone

Colour changes were measured with a spectrophotometer (Vita Easyshade Advance 4.0, Germany) using the CIEDE2000 formula [27] (Figure 1) at the following four times: Day 1, 7, 14 and 28. $\Delta L'$, $\Delta C'$ and $\Delta H'$ are described the differences in lightness, chroma and hue between specimens at different time periods.

Figure 1: CIEDE2000 colour formula

$$\Delta E_{00} = \left[\left(\frac{\Delta L'}{K_L S_L} \right)^2 + \left(\frac{\Delta C'}{K_C S_C} \right)^2 + \left(\frac{\Delta H'}{K_H S_H} \right)^2 + R_T \left(\frac{\Delta C'}{K_C S_C} \right) \left(\frac{\Delta H'}{K_H S_H} \right) \right]^{\frac{1}{2}}$$

Microleakage Measurement

Microleakage scores were evaluated using a dye penetration technique. All the specimens were coated with two layers of transparent nail varnish, leaving a 1 mm space around the cavity margins. Samples were dyed with a 0.2% Rhodamine B (Gunduz Chemistry, Istanbul, Turkey) for 24 hours. After the storage, the samples were rinsed, dried and cutted bucco-lingually with a water-cooled, slow-speed diamond blade (Mecatome T180, Presi, France). A stereomicroscope (SMZ1000, Nikon, Japan) was used to determine microleakage values under x40 magnification according to the 4-grade scale (Table 2).[28]

Table 2. Dye Penetration scores used in the study

Dye Penetration Scores
Score 0: no leakage
Score 1: dye penetration to the enamel or cementum aspect of the preparation wall
Score 2: dye penetration to the dentin aspect of the preparation wall, but not including the pulpal wall
Score 3: dye penetration including the pulpal wall of the preparation

Statistical analyses

Data were analyzed with IBM SPSS V23. Generalized linear models method was used to compare Delta E values according to group and time.The test of normality was performed using the Shapiro-Wilks test. Multiple comparisons were analyzed with the Tukey HSD test. Analysis results were presented as mean ± standard deviation. The significance level was taken as $p<0.050$. Kruskal Wallis test was used to analyze microleakage values.

RESULTS

When compared to the groups according to the ΔE_{00} values, statistically significant difference was found between Group 1and Group 3 (p=0.020). The highest colour change was observed in Group 2 at the end of the 28th day.

According to the effect of time period on total ΔE_{00} values, a significant difference was found between 1-7 and 1-28 days, 1-14 and 1-28 days (p<0,001).

When comparing the groups according to the time period, a significant differences were found in Group 2, between 1-7 and 1-14, 1-7 and 1-28 days. (p<0,001).

Multiple comparisons of ΔE values were shown in Table 3.

Table 3. Comparison of ΔE_{00} values between groups

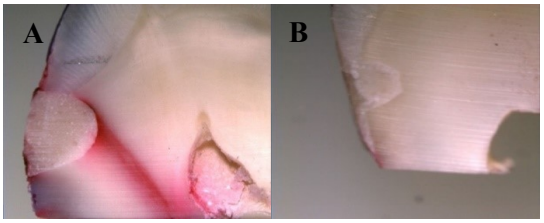
Time period	Groups				Total
	Group 1	Group 2	Group 3	Group 4	
1-7. Day	9.29 ± 3.54^{A}	2.8 ± 1.32^{C}	6.78 ± 1.25^{AB}	7.18 ± 2.01^{AB}	6.51 ± 3.2^{b}
1-14. Day	6.44 ± 1.69^{ABC}	7.34 ± 1.25^{AB}	5.01 ± 1.26^{BC}	5.15 ± 1.71^{BC}	5.98 ± 1.73^{b}
1-28. Day	8.99 ± 4.26^{A}	9.81 ± 2.03^{A}	7.69 ± 1.77^{AB}	7.69 ± 4.11^{AB}	8.55 ± 3.25^{a}
Total	8.24 ± 3.48^{a}	6.65 ± 3.32^{ab}	6.49 ± 1.8^{b}	6.67 ± 2.94^{ab}	7.01 ± 3.01

A-C: There is no difference between interactions with the same letter. a-b: No difference between with the same letter.

No significant difference was observed in terms of microleakage values at the gingival surface beween the groups (Table 4).

For microleakage values at occlusal surface, SDF and laser combined used group (Figure 2A) showed significantly higher microleakage values than Group 4 (Figure 2B) (control) group (p=0.011) (Table 4).

Figure2A: Representive microscopic image of tooth of Group II with score 3 both occlusal and gingival margins. **Figure2B**: Respresentive microscopic image of tooth of Group IV with score 0 on the occlusal marginal and score 1 on the gingival margin



The highest microleakage values were observed both of gingival and occlusal surface in SDF and laser combined used group (Table 4).

Table 4. Pairwise comparison of groups concerning microleakage (p<0.05)

	Groups				
	Group 1	Group 2	Group 3	Group 4	p
	Mean ± SS	Mean ± SS	Mean ± SS	Mean ± SS	
gingival	1.06 ± 0.93	1.56 ± 0.89	1.62 ± 1.26	1.06 ± 0.93	0.224
occlusal	0.81 ± 0.66^{ab}	1.38 ± 0.72^{ab}	1.62 ± 1.02^{a}	0.75 ± 0.86^{b}	**0.011**

Kruskall Wallis H test, a-b: No difference between with the same letter.

DISCUSSION

The SDF application has been commonly used and researched in children.[28] Besides to caries-arresting and antibacterial effect of SDF, it plays a role in the desentisizing of dentin tubules.[15,29] Castillo et al. concluded that SDF showed safe and effective performances on DH in their study.[30] Due to of desensitization property, it is conceivable that SDF could be used as a desensitizer prior to the restoration of non-carious cervical lesions. Also, Sinha et al. reported that SDF can be used as a remineralization agent and indirect pulp capping process. [31]

Spectrophotometers are frequently used to determine and evaluate colour change objectively.[32] CIElab and CIEDE2000 systems are frequently used in the calculation of colour differences. In this study, colour measurement was calculated with the CIEDE2000 system. In studies, it was reported that the CIEDE2000 system provides better detectability and acceptability than the CIELab in the evaluation of translucency and colour change in dental materials.[33,34]

Colour stability is an important factor for restorative materials. In the study conducted by Paravina et al, [27] they reported that according to the CIEDE2000 system, the clinically acceptable threshold value was determined to be greater than 1.8. In all of the tested groups, the ΔE_{00} values were above the clinically acceptable value at all time periods.

The one of noted side effects of SDF is discolouration [15]. It is also recommended to use KI solutions for reducing discolouration before restoration in root surface lesions when SDF is going to be used for desensitization. Roberts et al. reported that the use of KI after SDF application had a reducing effect on discolouration.[35] Nguyen et al. found that the use of KI after SDF application had a reducing effect on the discolouration of various restorative materials used in the restoration of Class I cavities.[36] However, it has been also reported that the use of KI has no effect on reducing discolouration.[15] In all groups using SDF, the colour change was found to be above the acceptable values even though KI containing solution was used. According to these results, the KI in green capsule was no effect in reducing discolouration. In the present study, colour change was observed significantly difference between Group 1 and Group 3. no So, null hypothesis 1 was rejected.

In the laser-used group, ΔE_{00} values were found significantly different between 1-7 and 1-14, 1-7 and 1-28 days. Also, the highest ΔE values were determined at the end of the 28th day in the laser-used group.

Tate et. al. mentioned that GaAlAs lasers might increase the deposition of tertiary dentin by odontoblast cells.[38] Liu et. al. found that the use of 980 nm diode laser on DH was more effective than the placebo.[39] In a study, comparing the effectiveness of 940 nm diode lasers with conventional desensitizer gels (fluoride stannous and potassium nitrate gel) on reducing DH, the 940 nm diode laser group showed the highest reduction.[40] In the present study, a 940 nm diode laser was also prefered to

reduce DH. Ranjan et al. used a 940 nm diode laser in one group and diode laser and SnF together in another group and found that the diode laser group was effective in decreasing DH and SnF can increase the efficiency of the laser.[41] Inspired by this approach, the combination of SDF and laser was used in this study.

Although there was no significant difference in microleakage values on the gingival surface between the laser group and the other groups, higher microleakage values were obtained in the laser-used group compared to the SDF-used and control group. Liu et al. reported that variation in dentin structure occurred due to temperature increase after laser irradiation.[39] The higher microleakage scores and ΔE values may be caused by this variation in dentin structure at laser-used groups.

The SDF and laser combined group showed significantly higher microleakage values than the control group. Besides this, the highest microleakage values were observed on both gingival and occlusal surfaces in the SDF and laser-combined groups. According to these results, the second hypothesis was partially accepted.

CONCLUSIONS

The study was performed under *in vitro* conditions without imitating the oral environment. Within this limitation, the followings can be concluded;

1. Although it was thought that the KI would mask the discolouration association with SDF, the colour changes were within unacceptable values in all groups that SDF used.
2. Colour changes in laser-applied groups were above the clinically acceptable values. In future studies, colour change can be evaluated after laser application with different parameters.
3. Highest microleakage scores were obtained at gingival and occlusal surfaces in the laser-used groups
4. Since both colour change and microleakage values are high in laser-used groups, the use of conventional agents (desensitizing gels, solutions, and pastes) for desensitization can be considered.

CONFLICT OF INTEREST

Ethical Approval

The necessary ethical approval for this study was received by the Istanbul Okan University Ethics Committee Non-Drug and Medical Device ethics committee (08.11.2023- Decision no: 13).

Financial Support

The authors declare that this study received no financial support.

Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: ZBK, HU, Data collection or access: ID, Analysis and comments: ZBK, Literature search: ZBK, ID, Writing: ZBK, ID.

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