Original Research

Evaluation of Diode laser (940 nm) irradiation effect on microleakage in class V composite restoration before and after adhesive application

Loghman Rezaei-Soufi[1], Shahin kasraei[2], Reza Fekrazad[3], Farshid Vahdatinia[4], Abbas Moghimbeigi[5], Mehdi Haddad[6], Marjan maleki[7]

[1]Assistant Professor, Department of Operative Dentistry, School of Dentistry, Hamadan University of Medical Sciences, Iran

[2]Department of Restorative Dentistry, Dental School, Shahid Beheshti University of Medical Sciences, Tehran, Iran

[3] Laser Research Center in Medical Sciences, AJA University of Medical Sciences, Tehran, Iran

[4]Laser Research Center, Dental School, Hamadan University of Medical Sciences, Hamadan, Iran

[5]Department of Biostatistics, School of Health, Hamadan University of Medical Sciences, Hamadan, Iran

[6]Private dentist, Neyshabur, Iran

[7]Department of Restorative Dentistry, Dental School, Hamadan University of Medical Sciences, Hamadan, Iran

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Abstract

Introduction: Nowadays, the main focus of dental studies is on adhesive dental materials; since clinical long-term success of bonded restorations depended more on marginal microleakage minimization. So, the aim of this study was Evaluation of Diode laser irradiation effect on microleakage in class V composite restoration before and after adhesive application. **Materials and methods:** In this in vitro-experimental study, standard class V cavity was prepared on lingual and buccal surfaces of 60 premolar teeth. For evaluation of microleakage, 60 teeth were divided randomly into four groups A, B, C, D (n=15): A) primer + adhesive (Clearfil TM SE Bond), B) primer + Diode laser + adhesive (940nm wave-length, 21J total energy, 0.7W power, 30s irradiation time) C) primer + adhesive + Diode laser D) primer + Diode laser + adhesive + Diode laser. Then, restoration was completed by Z250 composite. For data analyzing, we used SPSS 16 software. For statistical analysis, we used Non-parametric Kruskal-Wallis & Mann-Whitney tests at 0.05% significance level. **Results:** According to non-parametric Kruskal-Wallis test, microleakage scores had not significant difference before and after laser irradiation on gingival margins (p=0.116). But, in occlusal margins the results were significant among the groups (p=0.015). Also according to non-parametric Mann-Whitney tests among the occlusal microleakage scores, group B and D (Diode laser irradiation after primer and Diode laser irradiation after primer and adhesive) showed significant results. **Conclusion:** This study findings showed that in 6th generation adhesives, Diode laser irradiation on self-etch primer before bonding have significant effect on reduction of occlusal marginal microleakage in class V cavities although there was no significant positive effect of Diode laser on gingival margins.

Keywords: Diode laser, Composite resins, Dental leakage, Operative Dentistry.

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Introduction

Nowadays, the use of various types of composites is preferred by both dentists and patients because of their beautiful appearance and conservative technique. Although mechanical and physical properties of such composites have been improved in recent years, the contraction of polymerization still is their main drawback (1).

Stress-induced "polymerization shrinkage" can lead to detachment of the dentin-composite junction and consequently marginal leakage will occur (2). Micro-leakage is a dynamic phenomenon which is mainly caused by the penetration of liquids, bacteria, and ionic compounds into the prepared cavity wall and restoration materials. This phenomenon has been regarded as the main cause of composite restoration failures, secondary caries, hypersensitivity, and pulp inflammations (3, 4) .In this regard, in recent years much attention has been paid to the use of adhesive systems in order to promote the dentine-composite junction, minimizing micro-leakage, and preparing dental cavities with the minimum amount of tissue removal (5).

Adhesive systems have been categorized into two main categories based on their methods of application and their connection mechanisms; self-etching adhesive systems and etch & rinse adhesive systems (1,2,6). In the former category, the dentin etching process does not carry out and the acidic monomers presented in the adhesive system etches the dentin and enamel surfaces and thereby facilitates the penetration of resin in the demineralized dentin (5). Accordingly, the self-etching adhesive systems are preferred because the rinsing and drying steps are deleted, the required time would be reduced, and also there are lesser opportunities for human errors to occur (7-9).

In recent years laser systems have found many applications in preparing and processing of surfaces of organic and inorganic materials (9, 10).

The first use of such systems in dentistry field went back to the beginning of 1960 decade and Laser application in dentistry has been increasingly increased during the recent two decades. Given the vast range of laser systems' capabilities, it can be utilized for various purposes in the field of dentistry. The followings are some dentistry-related processes which can be performed using laser systems; the preparation of dental cavities, caries removal, removal of previous restoration, etching of enamel and dentin surfaces, treatment of hypersensitivity, caries prevention, and bleaching (10-13).

Having a wide range of frequency, capability in shaping material surfaces, high energy density, and capability of being concentrated on a point are some of the advantages that laser systems benefit from, and why such systems have found many applications in various area (9).

The most conventionally used laser systems in dentistry include CO2 laser, Nd:YAG (Neodymium: Yttrium-Aluminum-Garnet), Erbium family lasers (Er: YAG and Er, Cr: YSGG), and Diode lasers (14). Diode laser system is a common one used prevalently in the dentistry field. It is utilized a semi-conductor media to produce a laser beam. Gallium-aluminum-arsenide (GaAlAs) is the best known type of semiconductor laser with a wavelength between 800 and 980 nm (15).

In recent years, dental researchers have made many attempts to investigate the effects of laser irradiation on the adhesive systems which have been located on the dentin surface before being polymerized by light. As far as we know, the research conducted by Goncalve et al has been the first one in which the effect of laser beams on adhesive systems are investigated (16, 17). Moreover, the studies to assess the effects of such systems on the micro-leakage rate are rare. Kawaguchi et al is one the few studies which have been conducted in this area, which reported no effect of laser systems on micro-leakage. Therefore, there is a need to conduct more studies in this area to find out how the laser systems can affect micro-leakage of composite restoration (18).

Accordingly, the present study was conducted to investigate the effect of Diode laser (940 nm) irradiation on micro-leakage of class V composite restoration before and after applying the bonding agent.

Materials and methods

In this experimental study, 60 human premolar teeth which were free of cavities, previous restorations, fractures, and wearing were selected to be investigated (19). Several steps were conducted to prepare the teeth for the study; 1. Soft tissues remaining on the teeth surface were removed by a hand scalar; 2. The teeth were thoroughly washed and cleaned by pumice; 3. They were examined under a light microscope for assuring that they met the inclusion criteria of the study; 4. They were disinfected by submerging under 0.2 percent thymol solution until 24 hours before the study; 5. After which they were placed in distilled water at room temperature.

Teeth preparation for investigating the micro-leakage

On the buccal and lingual surfaces of each tooth a standard U-shape cavity with dimensions of 1.5 mm (buccolingual) * 3 mm (mesiodistal) * 2 mm (occlusoginigval) was created utilizing a Diamond Cylindrical Grinding device (Tizkavan Tehran, Iran) and a high speed handpiece (BienAir, Switzerland). The cavity was created so that its occlusal margin was

1 mm above CEJ and its gingival margin was 1 mm lower than CEJ.

Groups of the study

In the next, the teeth were randomly categorized into four equal groups (A, B, C, D) according to the Simple randomization method (Roll of a die);

- Group A (control group): primer + bonding agent + composite

In accordance with the manufacturer (Kuraray Dental, Japan), the primer was implemented for 20 seconds. Then, air drying was done and the bonding agent (Kuraray Dental Clearfil SE Primer, Japan) was located on the cavity surface of the teeth. Next, the teeth were cured using Demetron A.2 (Kerr, Germany) for ten seconds at 1100 mW/cm2. Samples were covered by resin composite (FiltekTMZ250, 3M ESPE, USA) with A2 color, height of 4 mm, and 2 mm thickness. Then, samples were cured for 40 seconds. At the end, the overall treatment was cured for 40 seconds again. The composite and bonding system (sixth generation, Clearfil SE bond, Kuraray, Japan) were the same for all groups.

- Group B: primer + Diode laser irradiation + bonding system + composite

All steps were the same as those of Group A, except that the diode laser irradiation was applied after the implementation of primer. The characteristics of the laser beam are presented in Table 1. Moreover, the laser beam was irradiated from a distance of 5 mm, by a sweeping motion, and for 30 seconds.

- Group C: primer + bonding system + Diode laser irradiation + composite

All the steps performed for treating the teeth of this group were the same as those used for the teeth of Group B, except that the diode laser irradiation was implemented after adding the bonding agent and before using the light polymerization. The characteristics of the laser beam were the same as those of group B (Table 1).

- Group D: primer + Diode laser irradiation + bonding system + Diode laser irradiation + composite

For treating the teeth of this group, the laser irradiation was used both before and after the implementation of bonding agent. Other procedures were the same as those of other groups.

Table 1. the characteristics of the laser beam

Wavelength	940 nm
Power	0.7 W
Time of irradiation	30 s
The laser spot size	0.017 mm^2
The surface area of the irradiated zone	21 mm^2
Total energy	21 J
Power density	39.7 W/cm^2
Energy density on the irradiated area	100 J/cm^2
Irradiation mode	Continuous
Tip	E4

Investigation of micro-leakage

The following steps were conducted in order to investigate the microleakage at each group; 1. Samples were submerged in water for 24 hours at 37 C; 2. The teeth were polished using special discs (Soflex, 3M ESPE, USA) and water; 3. Samples were exposed to 5-55 C heat cycles for 1000 times in a thermal bath (Nemo Mashhad, Iran) with a dwell time of 30 seconds and a transfer time of 5 seconds; 4. All teeth surfaces as well as mesial and distal surfaces were covered by two layers of nail varnish; 5. The samples were submerged in a basic fuchsine dye solution at room temperature for 24 hours; 6. After this period of time, samples were washed by water stream for 5 minutes; 7. To fuchsine dye to be stabilized, the samples were dried by placing at room temperature for 24 hours; 8. In the next step, the teeth were cut into two parts by a cutting machine (Nemo Mashhad, Iran); 9. Finally, the teeth were assessed by a Stereo microscope (Olympus SZX16, Japan) at a magnification of 40× to rank their status in terms of microleakage based on the following criteria; (Fig 1,2).

0- There was no penetrated dye in the tooth

1- The penetration of dye in the gingival or occlusal directions was less than 1/3 cavity wall.

2- The penetration of dye in the gingival or occlusal directions was between 1/3-2/3 cavity wall.

3- The penetration of dye in the gingival or occlusal directions were higher 2/3 but not reached the axial surface.

4- The penetration of dye was reached the axial surface.

Statistical analysis

In the present study, non-parametric Kruskal-wallis and Mann-Whitney tests were employed to compare the groups.

Results

For assessing the difference among the groups in terms of their microleakage level from the gingival margin (Table 2), Kruskal-wallis nonparametric test was employed, which showed no significant difference among the groups (p-value=0.116), so no further analysis was conducted (Table 3).

The same test was used to assess the difference among groups in terms of their microleakage level from occlusal margin, the results indicated a significant difference (p=0.015), so the analysis was followed by Mann-Whitney test to compare the groups in a pairwise manner. Table 4 represents the results of Mann-Whitney test, performed to compare the groups with each other in terms of their microleakage from occlusal margin status. As evident in this table, there was a significant difference between group A (control group) and group B (in which the laser beam was irradiated after the primer) (p=0.029). Moreover, the difference between group A and group D was also of significant importance (p=0.041). Furthermore, there was a significant difference between group B (in which the laser beam was irradiated after the primer) and group C (in which the laser beam was irradiated after the implementation of bonding agent) (p=0.029). The difference between group C and group D was also significant (p=0.037).

Table 2. Frequency distributions of microleakage scores (percentages) on occlusal and gingival margins among the different groups tested.

Groups		Score 0	Score 1	Score 2	Score 3	Score 4
Group A	Occlusal	5 %33.3	3 %20	3 %20	1 %6.6	3 %20
	Gingival	2 %13.3	3 %20	3 %20	3 %20	4 %26.6
Group B	Occlusal	10 %66.6	4 %26.6	0 %0	1 %6.6	0 %0
	Gingival	6 %40	4 %26.6	2 %13.3	2 %13.3	1 %6.6
Group C	Occlusal	7 %46.6	3 %20	2 %13.3	1 %6.6	2 %13.3
	Gingival	3 %20	5 %33.3	3 %20	3 %20	1 %6.6
Group D	Occlusal	10 %66.6	3 %20	2 %13.3	0 %0	0 %0
	Gingival	5 %33.3	5 %33.3	4 %26.6	1 %6.6	0 %0

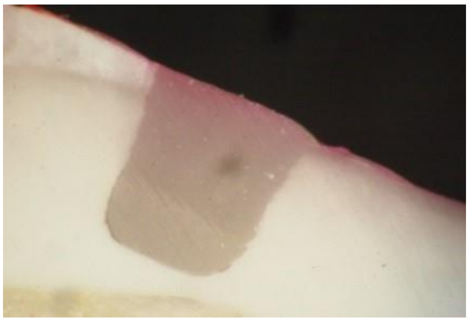

Figure 1. A typical sample with a microleakage level equal to rank 0

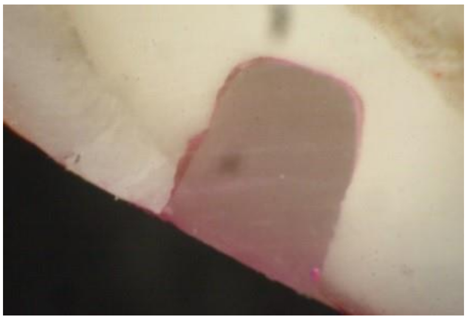

Figure 2. A typical sample with a microleakage level equal to rank 4

Table 3.The results of Kruskal-Wallis test for comparing the amount of gingival and occlusal marginal microleakage

Gingival leakage	Mean Rank	Number	P value
Group A	38.37	15	
Group B	27.63	15	
Group C	31.97	15	0.116
Group D	24.03	15	

Occlusal leakage	Mean Rank	Number	P value
Group A	37.23	15	
Group B	23.37	15	0.015
Group C	37.33	15	
Group D	24.07	15	

Table 4. The results of Mann-Whitney tests for comparing the groups with each other

Groups (ranking based on microleakge status)	Compared to	p.value
Group A (control) (rank 0)	Group B (laser beam irradiation after the primer)	0.029
	Group C (laser beam irradiation after applying the bonding agent)	0.93
	Group D (laser irradiation after applying primer and bonding agent)	0.041
Group B (laser beam irradiation after the primer) (rank 1)	Group C (laser beam irradiation after applying the bonding agent)	0.029
	Group D (laser irradiation after applying primer and bonding agent)	0.93
Group C (laser beam irradiation after applying the bonding agent) (rank 2)	Group D (laser irradiation after applying primer and bonding agent)	0.037

Discussion

In the present study, we attempted to evaluate the effect of Diode laser (940 nm) irradiation on microleakage of class V composite restoration before and after applying the bonding agent and find the best way through which the maximum utilization would be achieved.

The results of the present study demonstrated that the use of Diode laser (940 nm) system after applying primer and before bonding agent implementation step improved the occlusal margin microleakage reduction significantly higher than what can be obtained from applying the ordinary protocol (control group).

Microleakage has been defined as the immigration and penetration of bacteria, liquids, chemicals, molecules, and ions from the dentin-composite junction (20, 21). Although various methods have been recommended so far for preventing such a phenomenon, none of them has been proved to be totally effective (22).

It has been demonstrated by many studies that Clearfil-SE Bond adhesive has an acceptable level of resistance against destruction, which can be due to a high percentage of camphorquinone presented in this adhesive leading into a favorable level of polymerization (23-25). Moreover, the presence of 10-Methacryloxy Decyl Dihydrogen Phosphate (10- MDP) complex as a functional monomer with high potential in making chemical bonds with hydroxyapatite particles may be another reason why such an adhesive has an acceptable level of quality and resistance to destruction (24, 26).

To obtain a better adhesion and a reduction of microleakage, laser systems can provide a wider microtentive area free from any smear layers which is why some researchers have recommended such systems to be used during restoration process (27, 28). However, in recent years some different laser-based procedures have been proposed for improving the adhesion of restorative material to the dental tissues. Gonçalves et al employed the laser irradiation before the polymerization step (17). In another study, kawaguichi et al utilized Nd: YAG laser irradiation to control microleakages from the Class V composite restorations (18).

As an alternative, Diode laser beam with a wavelength close to infrared wavelengths (940 nm) and characteristics similar to those of Nd: YAG can be utilized for accomplishing the same purposes. Diode laser system has several advantages which make it an interesting option such as portability, availability in the market, small size, low weight, and a lower price compared to other counterparts (19).

The results of the present study demonstrated that using laser irradiation had no effect on the microleakage level of the gingival margin. The results are in line with those of Kawaguchi et al, as they also reported no effect from Nd:YAG laser beam irradiation on the microleakage level, regardless of the step in which the laser irradiation is applied (18).

The same results were reported by the study carried out by Araujo et al, in which it was explained that the highest level of microleakage was associated with the group which had been treated by applying laser beam irradiation after the implementation of primer and bonding agent (29). In contrast, Navarro et al explained that the use of Nd:YAG laser beam irradiation in restorative treatments improved the margin sealing and reduced microleakage level (30). Moreover, some studies have postulated that the irradiation of laser beam would improve quality of the substrate in the way that the dentin and adhesive are completely fused together, leading to the dentinal tubules to be closed and thereby reduce microleakage level (31). Franke et al, notified that the irradiation of Nd:YAG beam at a low energy density after the implementation of adhesive and before the polymerization had a positive effect on treatment outcome (32). Accordingly, using a laser system with characteristics different from those used by previous studies can be suggested as a possible explanation why we did not find a significant difference among the groups in terms of microleakage from gingival margin. For example, the power of laser system used by Navarro et al, was 1.2-2 W, while the power of diode laser system used in the present study was about 0.7 W (30). However, it should be noted that the use of high power laser beam can fuse the dentin substrate and restorative materials. The temperature changes occur in pulp chamber is another issue that should be taken into account when a high power laser beam is used (33).

According to the results of the present study, the irradiation of diode laser beam after the implementation of primer and bonding (groups B and D) reduced the microleakage level from the occlusal margin. The results are consistent with those of Wen, Obeidi, Navarro, and White (30, 34-36). Moreover, the results of the present study demonstrated that the reduction in microleakage from occlusal margin of cavities with enamel margins were higher than those cavities with gingival margins, which is in line with those reported by Hepdeniz and Ansari . This finding can be explained by considering the fact that dentin is a more complex structure than enamel is and the presence of water between collagen fibers prevents the resin components from penetrating into dentin tissue, and consequently, the microleakage level would increase in gingival margins with dentin margins (37, 38). Therefore, the reason behind microleakage reduction can be the sealing improvement of connective surfaces because of the high temperature provided by laser irradiation, which facilitates the penetration of adhesive components into the tubules of etched dentin (39). This high temperature can also cause the primer solvent to be evaporated that reduces the negative effects water and other solvent components have on the linkages between dentin and restorative materials (40, 41). These explanations are in line with what reported by Reis et al (42).

In this regard, Franke and Marimoto (32, 43). have explained the role played by heat and hot air in increasing the penetration depth of adhesive systems and thereby improving bond strength. The local hot spot created by Diode laser irradiation can promote the transformation of adhesive. Similar to the present study, Maenosono et al (19). also have observed that the application of Diode laser beam after the bonding step would improve bond strength, mainly because of the heat produced in adhesive as a result of laser beam absorption. They also postulated that the absorption of laser beam by adhesive can create a new substrate which improves the dentin-adhesive bond strength. The heat produced by laser system and the low viscosity of the primer are two possible causes why an improvement in penetration depth of primer followed by an increased penetration of the bonding agent was observed.

Conclusion

In conclusion, irradiation of diode laser beam on sixth generation's adhesive systems, Clearfil SE Bond, has no significant effect on microleakage level of gingival margin of class V cavities. However, the effects are significant on the occlusal margin when the laser beam is irradiated after the primer and before the application of bonding agent.

References

1. Medić V, Obradović-Đuričić K, Dodić S, Petrović R. In vitro evaluation of microleakage of various types of dental cements. Srpski arhiv za celokupno lekarstvo 2010; 138(3-4): 143-9.
2. Sánchez-Ayala A, Farias-Neto A, Vilanova LSR, Gomes JC, Gomes OMM. Marginal microleakage of class V resin-based composite restorations bonded with six one-step self-etch systems. Brazilian oral research 2013; 27(3): 225-30.
3. Baygin O, Korkmaz FM, Arslan I. Effects of different types of adhesive systems on the microleakage of compomer restorations in Class V cavities prepared by Er, Cr: YSGG laser in primary teeth. Dental materials journal 2012; 31(2): 206-14.
4. Van Meerbeek B, Vargas M, Inoue S, Yoshida Y, Peumans M, Lambrechts P, et al. Adhesives and cements to promote preservation dentistry. Operative Dentistry 2001; 26: 119-44.
5. 5. Kugel G, Ferrari M. The science of bonding: from first to sixth generation. The Journal of the American Dental Association 2000; 131: 20S-5S.
6. Nair M, Paul J, Kumar S, Chakravarthy Y, Krishna V. Comparative evaluation of the bonding efficacy of sixth and seventh generation bonding agents: An In-Vitro study. Journal of conservative dentistry: JCD 2014; 17(1): 27.
7. Watanabe I, McBride M, Newton P, Kurtz KS. Laser surface treatment to improve mechanical properties of cast titanium. dental materials. 2009; 25(5): 629-33.
8. Dilber E, Malkoc MA, Ozturk AN, Ozturk F. Effect of various laser irradiations on the mineral content of dentin. European journal of dentistry 2013; 7(1): 74.

9. Hashim NT, Gasmalla BG, Sabahelkheir AH, Awooda AM. Effect of the clinical application of the diode laser (810 nm) in the treatment of dentine hypersensitivity. BMC research notes 2014; 7(1): 31.
10. Eugénio S, Osorio R, Sivakumar M, Vilar R, Monticelli F, Toledano M. Bond strength of an etch-and-rinse adhesive to KrF excimer laser-treated dentin. Photomedicine and laser surgery 2010; 28(1): 97-102.
11. Çelik Ç, Özel Y, Bağış B, Erkut S. Effect of laser irradiation and cavity disinfectant application on the microtensile bond strength of different adhesive systems. Photomedicine and laser surgery 2010; 28(2): 267-72.
12. Srivastava VK, Mahajan S. Diode lasers: A magical wand to an orthodontic practice. Indian Journal of Dental Research 2014; 25(1): 78.
13. Oskoee SS, Oskoee PA, Navimipour EJ, Ajami AA, Azar FP, Rikhtegaran S, et al. Comparison of the effect of Nd: YAG and diode lasers and photodynamic therapy on microleakage of class V composite resin restorations. Journal of dental research, dental clinics, dental prospects 2013; 7(2): 74.
14. Ghiggi PC, Dall Agnol RJC, Burnett Júnior LH, Borges GA, Spohr AM. Effect of the Nd: YAG and the Er: YAG laser on the adhesive–dentin interface: a scanning electron microscopy study. Photomedicine and laser surgery 2010; 28(2): 195-200.
15. Nalcaci R, Cokakoglu S. Lasers in orthodontics. European journal of dentistry 2013; 7(Suppl 1): S119.
16. Castro FL, Andrade MF, Hebling J, Lizarelli RF. Nd: YAG laser irradiation of etched/unetched dentin through an uncured two-step etch-and-rinse adhesive and its effect on microtensile bond strength. Journal of Adhesive Dentistry 2012; 14(2): 137.
17. DE PAIVA GONÇALVES SE, DE ARAUJO MAM, DAMIÃO ÁJ. Dentin bond strength: influence of laser irradiation, acid etching, and hypermineralization. Journal of clinical laser medicine & surgery. 1999; 17(2): 77-85.
18. Kawaguchi F, Eduardo C, Matos A. Nd: YAG laser influence on microleakage of class V composite restoration. Journal of clinical laser medicine & surgery 2003; 21(4): 227-9.
19. Maenosono RM, Bim Junior O, DUARTE MAH, Palma-Dibb RG, Wang L, Ishikiriama SK. Diode laser irradiation increases microtensile bond strength of dentin. Brazilian oral research 2015; 29(1): 01-5.
20. Alani AH, Toh CG. Detection of microleakage around dental restorations: a review. Oper Dent 1997; 22(4): 173-85.
21. Bauer J, Henson JL. Microleakage: a measure of the performance of direct filling materials. Operative dentistry 1984; 9(1): 2.
22. Retief D, Mandras R, Russell C. Shear bond strength required to prevent microleakage of the dentin/restoration interface. American journal of dentistry 1994; 7(1): 44-6.
23. Rosales-Leal J, De la Torre-Moreno F, Bravo M. Effect of pulp pressure on the micropermeability and sealing ability of etch & rinse and self-etching adhesives. Operative dentistry 2007;32(3):242-50.
24. Yeganeh LAB, Tabai ES, Basir MM. Bonding durability of four adhesive systems. Journal of dentistry (Tehran, Iran) 2015; 12(8): 563.
25. 25. Osorio R, Pisani-Proenca J, Erhardt MCG, Osorio E, Aguilera FS, Tay FR, et al. Resistance of ten contemporary adhesives to resin–dentine bond degradation. Journal of dentistry 2008; 36(2): 163-9.
26. Watanabe T, Tsubota K, Takamizawa T, Kurokawa H, Rikuta A, Ando S, et al. Effect of prior acid etching on bonding durability of single-step adhesives. Operative dentistry 2008; 33(4): 426-33.
27. Visuri S, Gilbert J, Wright D, Wigdor H, Walsh Jr J. Shear strength of composite bonded to Er: YAG laser-prepared dentin. Journal of Dental Research 1996; 75(1): 599-605.
28. DOSTÁLOVÁ T, JELÍNKOVÁ H, KUČEROVÁ H, KREJSA O, HAMAL K, KUBELKA J, et al. Noncontact Er: YAG laser ablation: clinical evaluation. Journal of clinical laser medicine & surgery 1998; 16(5): 273-82.
29. Araujo RM, de Paula Eduardo C, Duarte Junior SLL, Araujo MAM, de Castro Monteiro Loffredo L. Microleakage and nanoleakage: influence of laser in cavity preparation and dentin pretreatment.

Journal of clinical laser medicine & surgery 2001; 19(6): 325-32.
30. NAVARRO RS, ESTEVES GV, OLIVEIRA Jr WT, MATOS AB, EDUARDO CP, YOUSSEF MN, et al. Nd: YAG laser effects on the microleakage of composite resin restorations. Journal of clinical laser medicine & surgery 2000; 18(2): 75-9.
31. Goodis H, White J, Marshall S, Marshall G, Lee F. Measurement of fluid flow through laser-treated dentine. Archives of Oral Biology. 1994;39:S128.
32. Franke M, Taylor A, Lago A, Fredel M. Influence of Nd: YAG laser irradiation on an adhesive restorative procedure. Operative dentistry 2006; 31(5): 604-9.
33. Zuerlein MJ, Fried D, Featherstone JD. Modeling the modification depth of carbon dioxide laser-treated dental enamel. Lasers in surgery and medicine 1999; 25(4): 335-47.
34. Obeidi A, Ghasemi A, Azima A, Ansari G. Effects of pulsed Nd: YAG laser on microleakage of composite restorations in Class V cavities. Photomedicine and Laser Therapy 2005; 23(1): 56-9.
35. Wen X, Liu L, Nie X, Zhang L, Deng M, Chen Y. Effect of pulse Nd: YAG laser on bond strength and microleakage of resin to human dentine. Photomedicine and laser surgery 2010; 28(6): 741-6.
36. White JM, Fagan MC, Goodis HE. Intrapulpal temperatures during pulsed Nd: YAG laser treatment of dentin, in vitro. Journal of Periodontology 1994; 65(3): 255-9.
37. Hepdeniz OK, Temel UB, Ugurlu M, Koskan O. The effect of surface sealants with different filler content on microleakage of Class V resin composite restorations. European journal of dentistry 2016; 10(2): 163.
38. Ansari ZJ, Motamedi MK. Microleakage of two self-adhesive cements in the enamel and dentin after 24 hours and two months. Journal of Dentistry (Tehran, Iran) 2014; 11(4): 418.
39. Holanda DBV, França FMG, do Amaral FLB, Flório FM, Basting RT. Influence of preheating the bonding agent of a conventional three-step adhesive system and the light activated resin cement on dentin bond strength. Journal of conservative dentistry: JCD 2013; 16(6): 536.
40. Sharafeddin F, Nouri H, Koohpeima F. The effect of temperature on shear bond strength of Clearfil SE Bond and Adper Single Bond adhesive systems to dentin. Journal of Dentistry 2015; 16(1): 10.
41. Nakabayashi N. Hybridization of dental hard tissues. The quality of hybridized dentin. 1998.
42. Reis A, Wambier L, Malaquias T, Wambier DS, Loguercio AD. Effects of warm air drying on water sorption, solubility, and adhesive strength of simplified etch-and-rinse adhesives. Journal of Adhesive Dentistry 2013; 15(1).
43. Marimoto A, Cunha L, Yui K, Huhtala M, Barcellos D, Prakki A, et al. Influence of Nd: YAG laser on the bond strength of self-etching and conventional adhesive systems to dental hard tissues. Operative dentistry 2013; 38(4): 447-55.

Corresponding Author:
Marjan maleki
DDS, MSc student, Department of Restorative Dentistry,
Dental School, Hamadan University of Medical Sciences, Hamadan, Iran.
Tell: +98912 443 8807
Email: dentistmarjan62@gmail.com