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Microleakage of Composite Resin Restorations in Class V Cavities Etched by Er:YAG Laser with Different Pulse Modes

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ABSTRACT

The aim of this study was to investigate the effect of different Er:YAG laser pulse modes on the microleakage of composite resin restorations using self-etch adhesive systems. Standard class V adhesive cavities were prepared on the buccal and lingual surfaces of sound human premolar teeth. The cervical cavity margins were below the CEJ. The teeth were randomly divided into three groups: Group 1; acid etching, Group 2; Er:YAG laser etching with MSP mode, Group 3: Er:YAG laser etching with QSP mode. Cavities were restored with a hybrid composite (Clearfil Majesty Posterior A3.5 Kuraray).

After thermocycling for 1000 cycles between 5°C and 55 °C, the specimens were stained with 0.5% aqueous basic fuchsin dye and sectioned bucco-lingually. Dye penetration was then scored. The data were analyzed using the Kruskal-Wallis and Mann-Whitney U tests with Bonferroni correction. The Wilcoxon signed ranks test was used to compare occlusal and gingival scores. Even though no statistically significant differences were found between any of the groups ($p>0.05$), the cavities etched with Er:YAG laser QSP mode showed less microleakage, and there were no significant differences between the microleakage at the dentin margins and the enamel margins in all groups ($P>0.05$).

Key words: Er:YAG laser, microleakage, quantum square pulse, QSP.

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I. INTRODUCTION

Recently, modern technologies for preparing dental hard tissues, such as laser irradiation, have become widespread. There has been growing interest in the use of lasers for routine cavity preparation and for conditioning enamel and dentin surfaces, the latter as an alternative to conventional acid etching methods [1,2]. Since the 1997 approval by the U.S. Federal Drug Administration of the use of Er:YAG lasers for caries removal, cavity preparation, and conditioning of tooth substance, there have been many reports on the use of this technique in combination with composite resins [3].

Given the unique topography created by laser interactions with dentin and enamel, it is possible that the surface alterations caused by laser irradiation may affect the microleakage of adhesive restorative materials. The integrity and durability of the marginal seal is an important factor in the longevity of adhesive dental restorative materials, particularly for composite resins. Microleakage induced by polymerization shrinkage continues to be a major concern for the clinical longevity of dental restorations. In the restoration of cervical lesions using composite resins, glass ionomer cements or compomers, studies have shown that marginal leakage was more severe at the gingival margin located in cementum or dentin than at the occlusal margin located in enamel [4,5]. Studies on surface alterations of enamel and dentin after Er:YAG laser irradiation demonstrated micro-irregularities on both tissues and the lack of a smear layer. Such alterations have both macro- and micro-roughness. Laser-induced changes in the surface texture of enamel and dentin could potentially affect the microleakage of adhesive restorative materials [6]. Although some studies have suggested that the effects of laser irradiation on dental mineralized structures are dependent on wavelength specificity, energy density, contact or non-contact mode of irradiation, and incidence angles [7-9], the adhesion of contemporary bonding agents to laser-irradiated dentin still remains a challenge since little is known about alterations in collagen fibrils and mineral content promoted by Er:YAG laser irradiation [10-18]. Recently it has become understood that the pulse duration and pulse energy of the Er:YAG laser are very important factors influencing the bond strength of an adhesive to enamel and dentin [19,20]. This understanding has re-motivated research efforts towards elimination of the acid-etching step of an etch-and-rinse adhesive [21].

The range of treatment parameters of Er:YAG lasers was significantly extended with the latest quantum square pulse (QSP) technology (Fotona, Slovenia). In the QSP mode, a longer laser pulse is divided, i.e. quantized, into several short pulses (pulse quanta) that follow each other at an optimally fast rate [22]. This enables the QSP mode to deliver short, low-energy pulses with the efficiency of long duration, higher energy laser pulses, without sacrificing the efficiency and precision that is provided by short duration pulses. One of the major advantages of the QSP mode is that it significantly reduces the undesirable effects of laser beam scattering and absorption in the debris cloud during hard-tissue ablation [22].

The aim of this study was to evaluate the effect of two different Er:YAG laser pulse modes (QSP and MSP mode) on the microleakage of class V composite restorations which were used to etch Class V cavities in premolar teeth. Microleakage scores at the enamel and dentin margins were evaluated to assess the influence of self-etch adhesive systems on the microleakage of composite restorations in class V cavities conditioning by Er:YAG laser.

II. MATERIALS AND METHODS

Fifteen caries free premolars of comparable dimension were selected for the experiments. The teeth were cleaned, using scalers and rotating brushes to remove soft-tissue remnants. The teeth were then stored in distilled water during the study.

Box-shaped, Class V cavities (2 mm in height, 4 mm in the mesiodistal direction and 2 mm in depth) were prepared in the buccal and lingual aspects of each tooth, using a 6-degree conical diamond bur (No: 8959KR.314.016, Gebr. Brasseler, Lemgo. Germany). Each preparation was designed with the occlusal margin in enamel and the gingival margin in dentin. No bevels were placed. After preparation the teeth were randomly divided into three groups.

Group 1: Acid etching; 37% ortofosforic acid was used for etching during 15 seconds, and specimens were washed and dried. Clearfil SE bond (CSE) (Kuraray, Osaka, Japan) two-step self-etch adhesive system was applied to cavities according to the manufacturer's instructions. Primer was applied for 20 seconds and gently dried. The bonding agent was then applied and light-cured for 10 seconds. Composite resin (Clearfil majesty posterior, Kuraray) was applied to the cavity and polymerized by LED curing unit for 20 seconds.

Group 2: Laser etching was applied to the cavity walls (1.2 watts, 10 Hz, MSP mode, delivered fluence per pulse 24 J/cm², with a non-contact handpiece with water and air cooling 50ml/min). Then the CSE self-etching bonding system similar to Group 1 was applied to cavities according to the manufacturer's instructions. Composite resin (Clearfil majesty posterior, Kuraray) was applied to the cavity and polymerized for 20 seconds.

Group 3: Laser etching was applied to the cavity walls (1.2 watts, 10 Hz, QSP mode, delivered fluence per pulse 24 J/cm² with a non-contact handpiece with water and air cooling 50ml/min). Then the CSE self-etching bonding system similar to Group 1 was applied to cavities according to the manufacturer's instructions. Composite resin (Clearfil majesty posterior, Kuraray) was applied to the cavity and polymerized for 20 seconds.

The surfaces of the restorations were finished with finishing diamonds (Finishing diamond, Diatech Dental AC, Heerbrugg, Switzerland) and polished with aluminum oxide polishing disks (Sof-Lex, 3M ESPE Dental Products, St. Paul, MN, USA). All specimens were then stored in distilled water at room temperature (24°C) for 24 hours.

Then the specimens were thermocycled for 1000 cycles between 5 °C and 55 °C using a dwell time of 30 seconds and transfer time 10 second. The teeth were then dried superficially and the apex of each tooth was sealed with composite resin. The exposed crown and root structure was covered with two coats of nail varnish, leaving a 1 mm window around the cavity margins. The specimens were then immersed in a solution of 0.5% basic fuchsin dye for 24 hours to produce a visible stain in the incubator (37°C). After this procedure, any surface-adhered dye was carefully rinsed away with tap water. Dye penetration around the specimens was used to determine the presence of a gap around the restoration. Then each tooth was sectioned longitudinally in a bucco-lingual plan through the center of the restoration with a water cooled, slow speed diamond blade (Mecatome T180, Presi, France) to obtain two sections of each tooth. The marginal sealing ability, as indicated by the depth of dye penetration around the enamel or dentin margins, was evaluated under a stereomicroscope (SZ-TP, Olympus, Japan) at 10x22 magnification. The following scoring scale was used to assess the extent of dye penetration at the tooth-restoration interface;

0: no leakage;
1: leakage extending to one-third of the depth of the restoration;
2: leakage extending to two-thirds of the depth of the restoration;

3: leakage extending to the floor of the restoration;
4: leakage extending beyond the floor of the restoration.

The results were tabulated and submitted to statistical analysis using the Kruskal–Wallis test (one way ANOVA) and Mann–Whitney U-test, a non-parametric variance analysis used to detect differences among the groups. The Wilcoxon's Signed Rank test was used to test microleakage of enamel and dentin at a level of significance of 5%.

III. RESULTS

In all specimens there was no leakage more than Score 1. Table 1 shows the microleakage scores of the groups. Comparing the three groups of etched cavities with regard to the microleakage, the Kruskal–Wallis test showed no difference among the groups (df=2; P=0.147). The ranking of groups according to the mean range (m.r.) of the Kruskal–Wallis test showed the best rank for group I (m.r.=14.6), then group III (m.r.=15.5) and lastly, group II (m.r.=21.4). Considering the microleakage of the surfaces (enamel or dentin), there were no statistically significant differences in all groups (Group I, p= 1.0; Group II, p=0.41; Group III, p= 0.063).

Table 1: Number of specimens showing microleakage

	Dentin margin		Enamel margin	
	Score 0	Score 1	Score 0	Score 1
Acid etching	6	4	7	3
MSP mode	2	8	4	6
QSP mode	8	2	10	0

IV. DISCUSSION

Microleakage is defined as the clinically undetectable passage of bacteria, fluids, molecules, or ions between a cavity wall and the restorative material applied to it [23]. This seepage can cause hypersensitivity of restored teeth, tooth discoloration, recurrent caries, pulpal injury, and accelerated deterioration of some restoration materials [24,25]. Some in vitro studies have already demonstrated the influencing role of adhesive systems on microleakage [26, 27]. The current in vitro study was carried out to further investigate the role of etching with different pulse modes of Er:YAG laser on microleakage in class V cavities in premolar teeth. The Class V cavities were located below the cement-enamel junction. The apical extent of the test cavities was intentionally placed into the root surface because leakage at this site is known to be a clinical concern when Class II and Class V cavities are restored with composite resin materials. Studies have shown that microleakage was greater on the gingival wall localized in dentin or cementum than on the occlusal wall [10, 17], however in the results of the current study there were no statistically significant differences between occlusal and cervical margins.

Pulse duration of the Er:YAG laser is a very important factor for bond strength of an adhesive to enamel and dentin, being directly related to the laser ablation ability and surface morphology [20]. As far as the laser equipment is concerned, an investigation showed that a shorter pulse duration of 35 μs results in significant higher bond strength than longer pulses of 200 μs [28]. Under scanning electron microscopy (SEM) the morphology of the cavities prepared by laser showed irregular enamel margins and dentin internal walls, and a more conservative pattern than that of conventional cavities, however the different power settings and pulse widths of Er:YAG laser in cavity preparation had no influence on microleakage of composite resin restorations [29]. Also in our study, QSP mode (Er:YAG laser) has resulted in less microleakage then MSP mode, however there were no statistically significant differences between the groups.

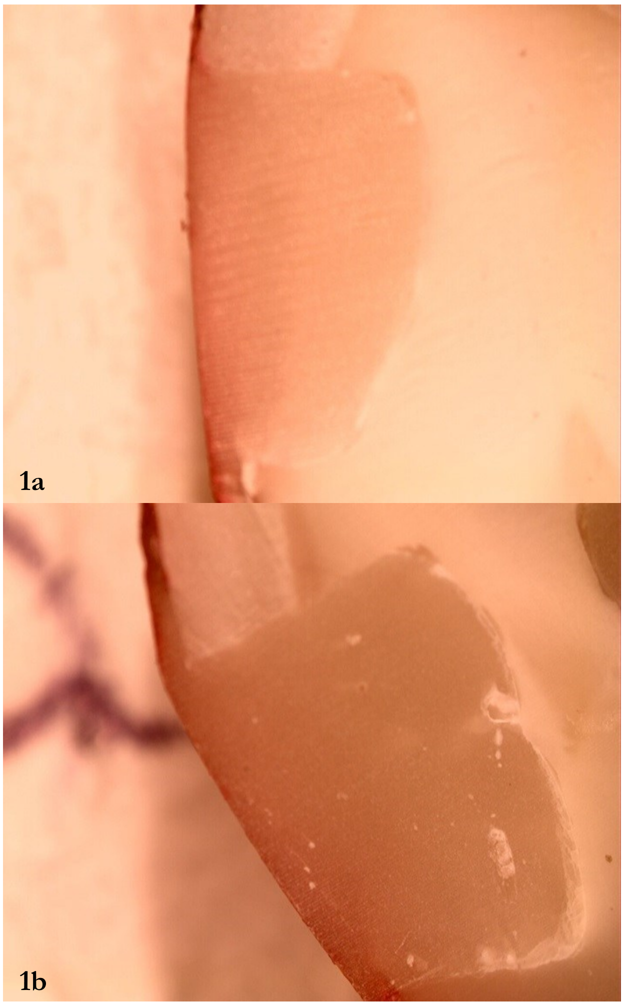

Fig. 1a, b: The specimen etched with QSP mode of Er:YAG laser; none of the specimens showed microleakage in the enamel margin of the cavity walls.

Delme et all [15] investigated microleakage in Class V cavities following restoration with conventional glass-ionomer cements or resin-modified glass-ionomer cements, following Er:YAG laser or conventional preparation. They found that the laser-prepared groups (with or without conditioning) restored with Fuji II LC and Fuji VIII allowed the least leakage at both margins. We used the Er:YAG laser in Class V cavities for conditioning, which were conventionally prepared with diamond bur and then restored with composite resin. The specimens etched with MSP mode showed microleakage in the enamel margin of 6 specimens and the dentin margin of 8 specimens (Fig. 2a,b) but none of the specimens etched with QSP mode showed microleakage in the enamel margin, and a dentin margin of 2 specimens showed that (Fig. 1a,b) QSP mode allowed less microleakage than MSP mode.

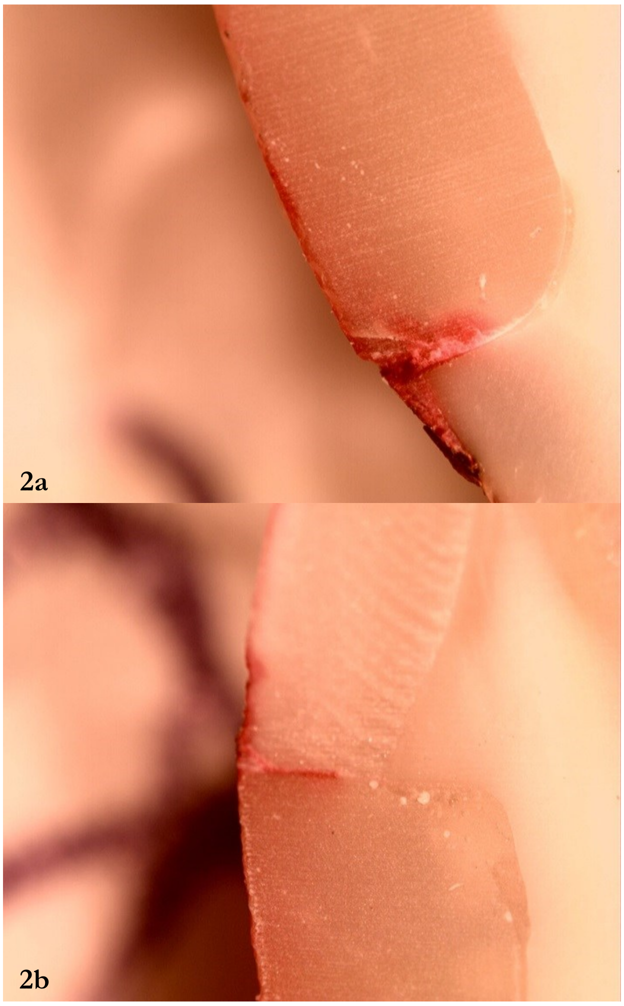

Fig. 2a, b: The specimen etched with MSP mode of Er:YAG laser; microleakage in both the enamel and gingival margins.

Due to inconsistencies in the published literature and the lack of data on the microleakage of self-etch dentin bonding with the Er:YAG laser's QSP and MSP modes, and the fact that the ultimate effect of laser irradiation on dental tooth substance is not yet fully understood, further studies are needed in this area.

V. CONCLUSIONS

The results obtained from this study show that: (1) the procedures tested did not completely eliminate microleakage, (2) Er:YAG laser etching with QSP mode was better than conventional acid-etching (Fig. 3a,b) and MSP mode, however, there were no statistically significant differences between them.

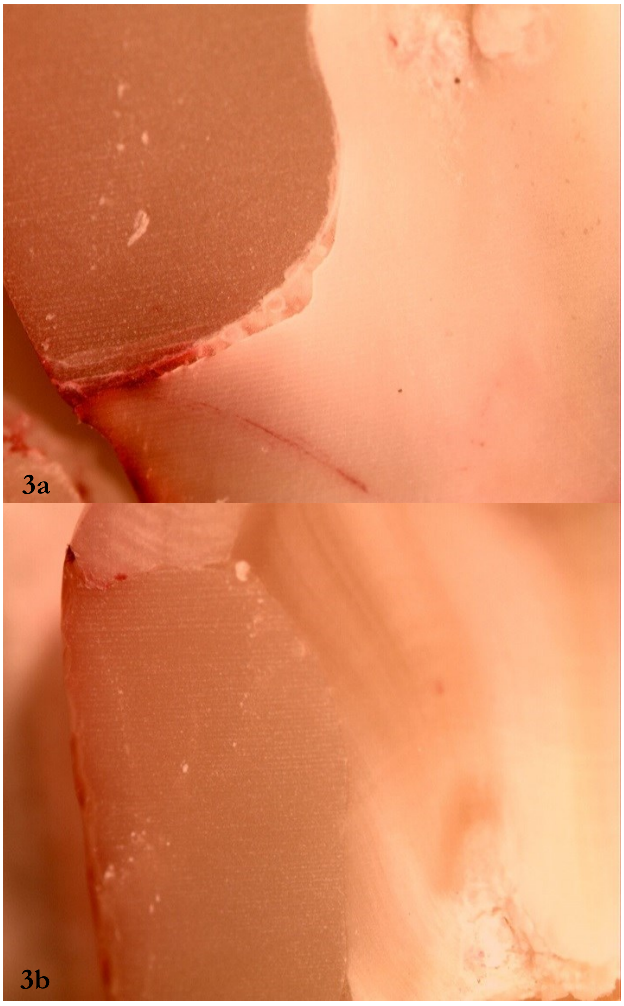

Fig. 3a,b: The specimen etched with acid; microleakage in both the enamel and gingival margins.

REFERENCES

1. Gutknecht N, Apel C, Schafer C, Lampert F. Microleakage of composite filling in Er,Cr:YSGG laser-prepared class II cavities. Lasers Surg Med 2001;28:371–374.
2. Apel C, Gutknecht N. Bond strength of composites on Er:YAG and Er,Cr:YSGG laser-irradiated enamel. In: SPIE proceedings Vol. 3564, Medical Application of Lasers in Dermatology, Cardiology, Ophthalmology and Dentistry II, 1999;197–200.
3. De Moor RJG, Delmé KIM. Erbium lasers and adhesion to tooth structure. J Oral Laser Appl 2006; 6: 7-21.
4. Santini A, Mitchell S. Effect of wet and dry bonding techniques on marginal leakage. Am J Dent 1998; 11:219-224.

5. Santini A, Mitchell S. Microleakage of composite restorations bonded with three new dentin bonding agents. J Esthet Dent1998; 10: 296-304.
6. Hossain M, Nakamura Y, Yamada Y, Kimura Y, MatsumotoN, Matsumoto K. Effects of Er,Cr:YSGG laser irradiation in human enamel and dentin: ablation and morphological studies. J Clin Laser Med Surg 1999; 17: 155-159.
7. Hibst R, Keller U. Experimental studies of the application of the ER:YAG laser on the dental hard substances: I measurement of the ablation rate. Lasers Surg Med 1989; 9:338–344.
8. Keller U, Hibst R. Experimental studies of the application of the Er:YAG laser on the dental hard substances: II light microscopic and SEM investigations. Lasers Surg Med 1989;9:345–351.
9. Oliveira MT, Arrais CA, Aranha AC, Paula Eduardo C, Miyake K, Rueggeberg FA, Giannini M. Micromorphology of resin dentin interfaces using one-bottle etch&rinse and self-etching adhesive systems on laser-treated dentin surfaces: a confocal laser scanning microscope analysis. Lasers in Surgery Medicine 2010; 42:662–670.
10. Corona SAM, Borsatto MC, Pécora JD, DeSaRocha RAS, Ramos TS, Palma-Dibb RG. Assessing microleakage of different class V restorations after Er:YAG laser and bur preparation. J Oral Rehab 2003;30:1008-1014.
11. Wright GZ, McConnell RJ, Keller U. Microleakage of class V composite restorations prepared conventionally with those prepared with an Er:YAG laser: a pilot study. Pediatr Dent 1993; 15:425-426.
12. Corona SAM, Borsatto MC, Dibb RG, Ramos RP, Brugnera AJr, Pécora JD. Microleakage on class V resin composite restorations after bur, air abrasion or Er:YAG laser preparation. Oper Dent 2001; 26:491-497.
13. Baygýn Ö, 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. Dent Mater J 2012;31(2): 206-214.
14. Siso HS, Kustarcý A, Göktolga EG: Microleakage in resin composite restorations after antimicrobial pre-treatments: Effect of KTP laser, Chlorexidine gluconate and clearfil protect bond. Oper Dent 2009;34(3): 321-327.
15. Delme KIM, Deman PJ, De Bruyne MAA, De Moor RJG. Microleakage of four different restorative glass Ionomer formulations in Class V cavities: Er:YAG laser versus conventional preparation. Photomed and Laser Surg. 2008; 26(6) 541-550.
16. Oliveira MT, Freitas PM, Paula Eduardo C, Ambrosano GM, Giannini M. Influence of diamond sono-abrasion, airabrasion and Er:YAG laser irradiation on bonding of different adhesive systems to dentin. Eur J Dent 2007; 1:158–166.
17. Ceballos L, Toledano M, Osorio R, Tay FR, Marshall GW. Bonding to Er-YAG-laser-treated dentin. J Dent Res 2002; 81:119–122.
18. Munck DJ, Meerbeek VB, Yudhira R, Lambrechts P, Vanherle G. Micro-tensile bond strength of two adhesive to Er:YAG laser vs. bur-cut enamel and dentin. Eur J Oral Sci 2002; 110:322–329.
19. Bahrami B, Askari N, Tielmans M, Heysselaer D, Lamard L, Peremans A, Nyssen-Behets C, Nammour S. Effect of low fluency dentin conditioning on tensile bond strength of composite bonded to Er:YAG laser-prepared dentin: a preliminary study. Lasers Med Sci 2011; 26: 187-191.
20. Firat E, Gurgan S, Gutknecht N. Microtensile bond strength of an etch-and-rinse adhesive to enamel and dentin after Er:YAG laser pretreatment with different pulse durations. Lasers Med Sci 2012; 27: 15-21.
21. Lukac M, Malej Primc N, Pirnat S. Quantum Square Pulse Er:YAG Lasers for Fast and Precise Hard Dental Tissue Preparation. J LAHA, 2012; 1: 14-21.
22. Gutknecht N, Lukac M, Marincek M, Perhavec T, Kazic M. A novel quantum square pulse (QSP) mode erbium dental laser. J LAHA. 2011;1: 15-21.
23. Kidd EA. Microleakage: A review. J Dent1976; 4:199-206.
24. Vicente A, Ortiz AJ, Parra PL, Calvo JL, Chiva F. Mictoleakage in Class V composite and compomer restorations following exposure to a colutory prescribed for the treatment of xerostomy. Odontology 2011; 99:49-54.
25. Mali P, Deshpande S, Singh A. Microleakage of restorative materials: an in vitro study. J Indian Soc Pedod Prev Dent 2006; 24: 15-18.
26. Gordan VV, Vargas MA, Cobb DS, Denehy GE. Evaluation of acidic primers in microleakage of Class V composite resin restorations. Oper Dent 1998; 23: 244-249.
27. Yap AUJ, Ho KS, Wong KM. Comparison of marginal sealing ability of new generation bonding systems. J Oral Rehab 1998,25:666-671.
28. Staninec M, Gardner AK, Le CQ, Sarma AV, Fried D. Adhesion of composite to enamel and dentin surfaces irradiated by IR laser pulses of 0.5-35 micros duration. Biomed Mater Res B Appl Biomater. 2006; 79(1):193-201.
29. Navarro RS, Gouw-Soares S, Cassoni A, Haypek P, Zezell DM, de Paula Eduardo C. The influence of erbium:yttrium-aluminum-garnet laser ablation with variable pulse width on morphology and microleakage of composite restorations. Lasers Med Sci. 2010; 25(6):881-9.