

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 buccolingually. 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 than MSP mode, however there were no statistically significant differences between the groups.

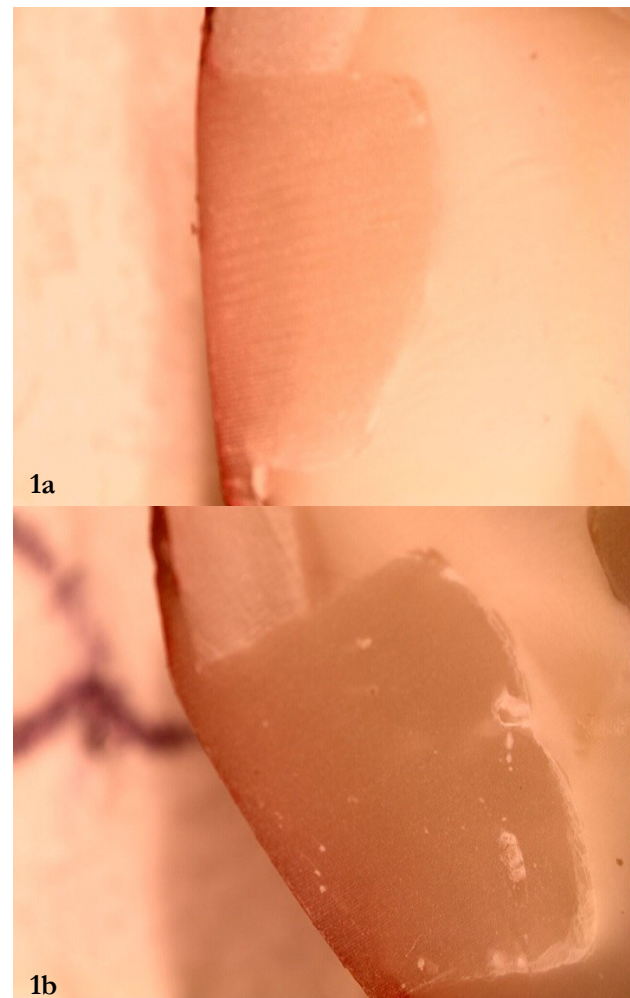


Fig. 1a, b: The specimen etched with QSP mode of Er:YAG laser; none of the specimens showed microleakage in the enamel margin of the cavity walls.

Delme et al [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.

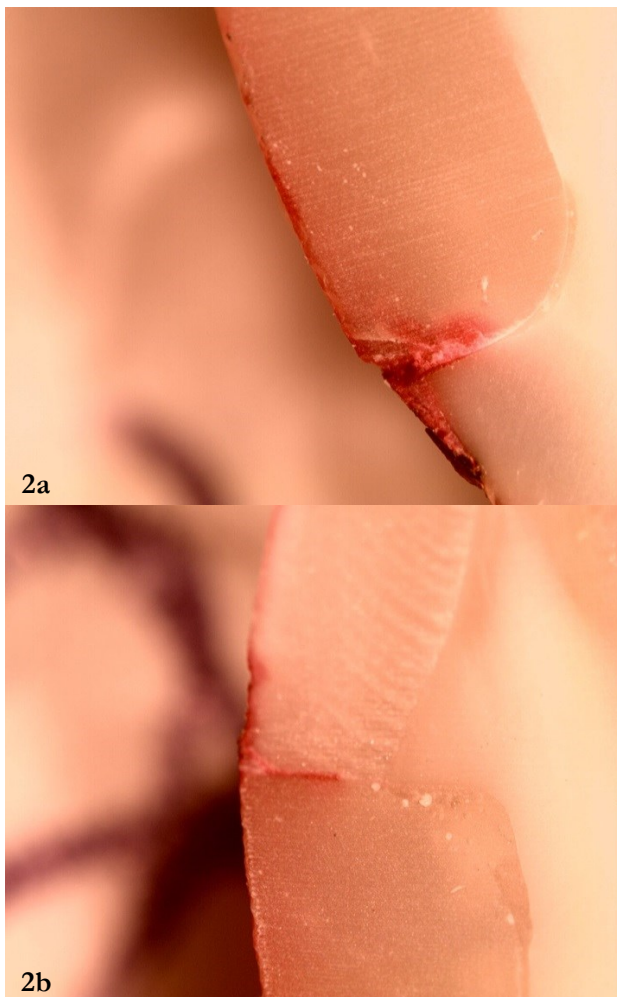


Fig. 2a, b: The specimen etched with MSP mode of Er:YAG laser; microleakage in both the enamel and gingival margins.

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.

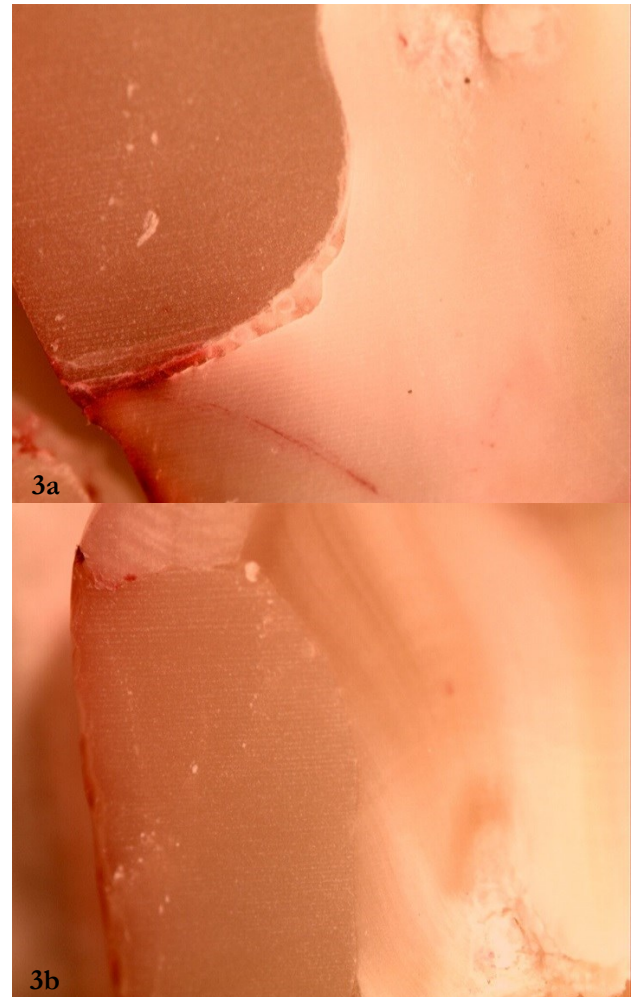


Fig. 3a,b: The specimen etched with acid; microleakage in both the enamel and gingival margins.

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