Microleakage of Class V compomer resin restorations after conventional diamond bur and Er, Cr:YSGG laser preparation

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ABSTRACT
Objectives: The aim of this study was to compared the microleakage of Class V compomer resin restorations prepared by Er,Cr:YSGG laser or conventional diamond bur.
Materials and Methods: Ninety sound primary molar teeth were randomly assigned to the six study groups, pretreated as follows: Group1:2W-10Hz Er,Cr:YSGG laser irradiation; Group2:2W-20Hz Er,Cr:YSGG laser irradiation; Group3:2,5W-10Hz Er,Cr:YSGG laser irradiation; Group4:2,5W-20Hz Er,Cr:YSGG laser irradiation; Group5: 3W-10Hz Er,Cr:YSGG laser irradiation; and Group6:3W laser-20Hz Er,Cr:YSGG laser irradiation. Each tooth hosted one test cavity prepared with one of the Er,Cr:YSGG laser irradiation and one control cavity prepared with a conventional diamond bur in a high-speed hand piece. Both cavities were placed at the cervical margin of the tooth and were restored and finished according to the manufacturer's instructions. All the restorations were subjected to thermocycling and load cycling. Microleakage was assessed using 0.5% basic–fuchsin solution and the specimens were sectioned longitudinally in buccolingual direction. Dye penetration was scored based upon the extent of the dye using a stereo-microscope. The data were analyzed using the Kruskal-Wallis and Wilcoxon Signed Ranks Test.
Results: There were no statistically significant differences in microleakage ($p>0.05$) at either enamel or dentine margins among experimental groups. Lased groups resulted with statistically significant less microleakage compared to controls at both enamel and dentine margins in Groups 4 and 6 ($p<0.05$).
Conclusions: 2,5W-20Hz and 3W-20Hz Er,Cr:YSGG laser irradiation may be an alternative to the conventional diamond bur for prevention of microleakage of compomer restorations.
Keywords: Er,Cr:YSGG laser, diamond bur, compomer, microleakage.

INTRODUCTION

The last 20 years have seen a decline in the caries experience of children in many parts of the world.[1] Despite an overall caries decline in children, 50–60% of carious primary teeth still remain untreated in 6-year-old children. In 3-year-olds, 87% are not appropriately filled.[2] Recent data about oral health in children and adolescents have demonstrated a significant caries increase in children between the ages of 12 and 15 years.[3] Therefore, early and simple restoration is very desirable, especially for individuals with a high risk of caries. Accordingly, in the primary and the early stages of the mixed dentition; anterior and posterior cavities are mostly restored with polyacid-modified composites, the so-called compomers.[4]

Compomers consist of conventional macromonomers, together with small amounts of functional monomers. The filler glass is identical to the ion-leachable glass fillers used in conventional glass ionomer cements, but in smaller sizes than are used in composites. Compomers are also capable of buffering aqueous acid

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solutions, raising their pH from acidic to nearly neutral, which together with fluoride release provides some protection against secondary caries.[5]

One of the biggest problems with restorative materials is microleakage, defined as the clinically undetectable passage of bacteria, fluids, molecules, or ions between the cavity walls and the restoration.[6] This seepage can cause hypersensitivity, tooth discoloration, recurring caries, and pulpal injury, and it can also accelerate the deterioration of the restorative materials themselves.[5,7] The relationship between marginal leakage in restorations and type of restorative materials used have been extensively studied both in clinical and laboratory experiments. In the absence of definitive clinical data, laboratory microleakage studies are a well-accepted method of screening adhesive restorative materials for marginal seal.[6,7] Microleakage investigation of compomers and their comparison with other materials have involved only a limited number of products but in general have shown adequately sealed restorations margins.[7,8] In addition, 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 play an important role in the longevity of adhesive dental restorative materials.[9] However, there is a consensus that any material or technique can not avoid microleakage completely.[10,11] In addition, the complicated structure in Class V cavities surrounded by dentine cemento enamel makes the selection of material difficult.[12] According to previous studies, it is reported that a material like compomer with low flexibility has the ability to prevent secondary caries and post-operative sensitivity due to its fluoride releasing; ability, thus, it requires less clinical time with less technique-sensitive applications due to isolation problems and, especially in servical regions, this material should be preferred.[13,14]

Manufacturers suggest that compomers are applied without etching procedures. However some of the microleakage studies showed that marginal adaptation of compomer restorations reduced without etching procedure.[8,15] In recent years, there has been growing interest in the use of lasers for routine cavity preparation and for conditioning enamel and dentine surfaces, the latter as an alternative to conventional acid etch methods.[16] While not to be useful for all restorative dentistry procedures, caries removal and cavity preparation with middle infrared lasers (Er:YAG and Er,Cr:YSGG) have replaced conventional high and low-speed dental drills in many situations, providing the same clinical effectiveness with reduced pain and discomfort by eliminating pressure, intense vibration, noise and in most cases, the need for injected local anaesthetic.[17] However, a reported universal barrier regarding children dental care is fear.[18] The most commonly expressed fears are the sight and sensation of the anaesthetic needle and the dental drill.[19] Furthermore, clinical studies have indicated that patients preferred the use of the laser and were less likely to require local analgesia when compared with conventional preparation with the high-speed drill and diamond bur.[20] It appears, therefore, that the laser irradiation may provide a useful adjunct to conventional cavity preparation.[21]

Studies on surface alterations of enamel and dentine after Er,Cr:YSGG laser irradiation demonstrate micro-irregularities on both tissues and lack of a smear layer.[9] Such alterations display both macro and micro-roughness. Laser-induced changes in the surface texture of enamel and dentine could potentially affect the microleakage of adhesive restorative materials.[22] In fact, given the increasing use of poly acid-modified resin materials in restorative dentistry, the quality of the margins of compomer restorations in terms of leakage is an important issue for clinicians considering the use of a laser for hard tooth tissue preparation.[23]

To date, there have been no reports on the influence of the Er,Cr:YSGG laser on the microleakage of poly acid-modified resin materials (compomers). These materials release fluoride and, by using a single component etch-and-rinse adhesive system, obviate the rinsing stage necessary for the application of earlier bonding agents, such as scotchbond multi-purpose (SMP). These properties have obvious advantages when managing the child patient.[21,23,24]

The aim of this study was to evaluate the influence of the Er,Cr:YSGG laser on the microleakage of Class V compomer restorations. The objectives were two folds: firstly, to compare the microleakage seen at the enamel and dentine margins of cavities prepared with one of the three laser power level and two frequencies; and secondly, to compare the pattern of the leakage seen at the lased margins with those that had been prepared conventionally diamond bur.

The null hypothesis tested in this study was that microleakages of compomer restorations would be similar among the Er,Cr:YSGG lased cavities at different power levels (inter-group) and also no differences exist between the bur and lased cavities in individual groups (intra-group) for enamel and dentine margins.

MATERIALS AND METHODS

Ninety sound, extracted, human primary molar teeth (at least 2/3 of the roots were present), free of caries assigned for extraction were extracted after obtaining the informed consent form signed by the patients. The teeth were stored in distilled water at 4ºC for a maximum of 1 month. To prevent bacterial growth, the water was changed once a week. After surface debridement with hand-scaling instruments and cleansing with a slow-speed hand piece and a brush with pumice, the teeth were randomly divided into six groups with fifteen teeth each (Table 1).

Table 1. Study groups.

Group No	
1.	**2W- 10 Hz Er. Cr: YSGG laser irradiation**
2.	**2W- 20 Hz Er. Cr: YSGG laser irradiation**
3.	**2,5W- 10 Hz Er. Cr: YSGG laser irradiation**
4.	**2,5W- 20 Hz Er. Cr: YSGG laser irradiation**
5.	**3W- 10 Hz Er. Cr: YSGG laser irradiation**
6.	**3W- 20 Hz Er. Cr: YSGG laser irradiation**

The buccal and lingual surfaces were cleaned with a rubber cup and polishing paste (Detartrine, Septodont, Saint-Maur, France) and then standardized Class V cavities were prepared at the cervical margins of each tooth, one being the test cavity and the other the control. Allocation of test and control cavities was random and cavity size was made as uniform as possible, 3 mm high, 1.5 mm wide and 2 mm deep, using metal templates. The control cavity was cut using a round diamond bur (model 801, size 012, Komet, Gebr. Brasseler, Lemgo, Germany) in a high-speed handpiece with water cooling, and the bur was changed every 15 cavities.

The test cavity preparation was made with a Er, Cr: YSGG laser system (Waterlase MD, Biolase Technology Inc., San Clemente, CA, USA) operating at a wavelength of 2,790 nm and having a pulse duration of 140–200 µs with a frequency rate of 10 Hz and 20 Hz. Laser energy was delivered through a fibreoptic system to a sapphire tip terminal 600 µm in diameter and 6 mm long with tip to target distance of 1 mm. For enamel and dentine cutting, the manufacturer's recommended settings were used, namely, for enamel 2W, 2.5W and 3W power, 95% air flow, 85% water flow, and for dentine 2W, 2.5W and 3W power, 75% air flow, 65% water flow.

The teeth were restored with the compomer resin, Dyract® eXtra (685402 Shade A3) Dentsply, Milford, DE, USA) and single-component etch-and-rinse bonding agent, Prime&Bond® *NT*™ Nano-Technology Light Cured Dental Adhesive (Dentsply, DeTrey, Konstanz, Germany) according to the manufacturer's instructions without etching with phosphoric acid. The compomer resin was applied in two increments, each light-cured for 40 s with a light intensity of 1200 mW/cm^2 (curing light XL 3000™, 3M Dental Products); the first two were applied obliquely against the occlusal and the gingival walls, respectively. The final increment was placed flush with the contour of the tooth and covered with a transparent cellulose acetate strip. Finishing was carried out immediately after polymerization using graded Soflex discs (3M Dental Products, St Paul, MN, USA) according to the manufacturer's instructions.

Following these procedures, all teeth were then placed in deionized water at 37°C for 24 h and thermocycled (500 times at 5± 2°C to 55±2°C; dwell time 15 s and transfer time 10 s). Finally, all teeth were stored in distilled water at 37°C for 24 hours to prevent dehydration. Marginal leakage was evaluated by a conventional dye-penetration method. The apices of the teeth were sealed with epoxy resin (Struers; Copenhagen, Denmark), and the specimens were covered with two coats of nail varnish up to 1 mm from the sealant margins to prevent dye infiltration. The specimens were then immersed in 0.5 % basic fuchsin solution (Wako Pure Chemical Industry; Osaka, Japan) for 24 hours at 37ºC.

After being rinsed with distilled water, each specimen was embedded in epoxy resin and subsequently sectioned longitudinally in a bucco-lingual plane through the mid-point of the restorations with a water-cooled, slow-speed, diamond saw (Mecatome T201; Presi, France) to provide two sections of each tooth. The cut sections were randomly examined under a stereo-microscope (Olympus SZ 40, SZ-PT, Japan) at ×20 magnification by two calibrated examiners, who were unaware of the groupings of the teeth, using the linear scoring criteria shown in Table 2. Both sections per tooth were examined, and the scores for both the enamel (coronal) and dentine (cervical) margins were used for data analysis.

Results were recorded and analyzed using the statistical package SPSS 14.0.0 for Windows (SPSS Inc., Chicago, IL, USA). Inter-examiner reproducibility was analyzed with the kappa statistic. The data were analyzed using the Kruskal-Wallis and Wilcoxon Signed Ranks Test. A value of $p < 0.05$ was considered significant.

RESULTS

The inter-examiner agreement had a kappa value of 0.88 for the sections. Leakage was seen in all groups at both the enamel and dentine margins. The distributions of marginal leakage scores according to groups are presented in Table 3. Descriptive statistics median (min-max) and statistical analysis are shown in Table 4.

Table 2. Criteria for microleakage scoring.

Score	Definition
0	No dye penetration
1	Dye penetration up to one-third cavity depth
2	Dye penetration up to two-thirds cavity depth
3	Dye penetration up to three-thirds cavity depth
4	Extensive dye penetration to and into pulpal floor/ axial wall

Table 3. Microleakage scores of all cavities.

		Conventionally prepared score					**Lased Score**				
Groups	**Margin**	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**
1	Enamel	7	5	2	1	0	8	4	2	1	0
	Dentine	6	4	3	1	1	7	5	2	0	1
2	Enamel	8	4	3	0	0	8	5	1	1	0
	Dentine	6	5	3	0	1	7	4	2	1	1
3	Enamel	7	5	2	1	0	9	2	2	2	0
	Dentine	6	5	2	1	1	8	5	1	1	0
4	Enamel	7	5	2	1	0	11	2	2	0	0
	Dentine	6	5	3	1	0	10	4	1	0	0
5	Enamel	8	4	2	1	0	9	3	2	1	0
	Dentine	7	6	2	0	0	9	4	1	0	1
6	Enamel	8	5	1	1	0	13	1	1	0	0
	Dentine	7	4	3	0	1	12	2	1	0	0

Table 4. Descriptive statistics for marginal microleakage.

	Enamel (Bur)	**Dentine (Bur)**	**Enamel (Laser)**	**Dentine (Laser)**
Groups	Median (Min-Max)	Median (Min-Max)	Median (Min-Max)	Median (Min-Max)
1	$1^{A,a}$(0-3)	$1^{B,b}$(0-4)	$0^{A,a}$ (0-3)	$1^{B,b}$ (0-4)
2	$0^{A,a}$ (0-2)	$1^{B,b}$ (0-4)	$0^{A,a}$ (0-3)	$1^{B,b}$ (0-4)
3	$1^{A,a}$ (0-3)	$1^{B,b}$ (0-4)	$0^{A,a}$ (0-3)	$0^{B,b}$ (0-3)
4	$1^{A,c}$ (0-3)	$1^{B,e}$ (0-3)	$0^{A,d}$(0-2)	$0^{B,f}$ (0-2)
5	$0^{A,a}$ (0-3)	$1^{B,b}$(0-2)	$0^{A,a}$ (0-3)	$0^{B,b}$ (0-4)
6	$0^{A,c}$ (0-3)	$1^{B,e}$(0-4)	$0^{A,d}$(0-2)	$0^{B,f}$ (0-2)

*In each column (each preparation technique) values with same superscript capital letters indicate no significant differences between the groups for enamel and dentine scores ($p>0.05$) and in each rows, the values with different superscript small caps indicate significant differences (Group 4; $p<0.014^{c,d}$, $p<0.005^{e,f}$, Group 6; $p<0.008^{c,d}$, $p<0.008^{e,f}$) whereas same superscript caps indicate no significant differences ($p>0.05$) for enamel and dentine scores of individual groups.

Inter-group evaluations revealed no statistically significant differences in microleakage ($p>0.05$) at either enamel or dentine margins among the groups (1-6). Intra-group evaluations also revealed that the lased cavities demonstrated statistically significant less microleakage compared to the control (bur) cavities at both enamel and dentine margins only in Groups 4 and 6, individually ($p<0.05$). Since the mostly ‘0’ scores were found in Groups 4 and 6 and no significant differences were found among the lased cavities (Group 1,2,3,4,5 and 6; $p>0.05$) at either enamel and dentine margins, stereomicroscopic images showing microleakage pattern between teeth and restoration at ×20 magnification are presented in Figures 1 and 2 (Groups 4 and 6).

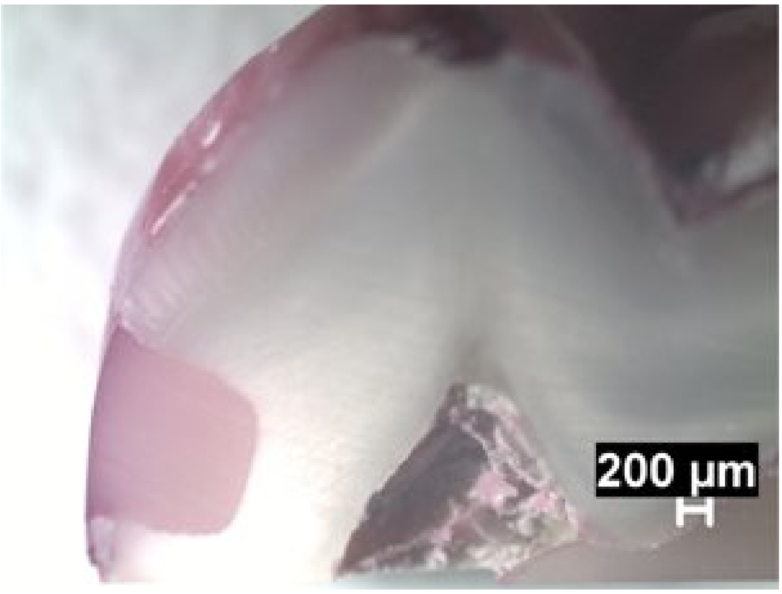

Figure 1. Stereomicroscopic images group 4 showing microleakage pattern between teeth and restoration at ×20 magnification.

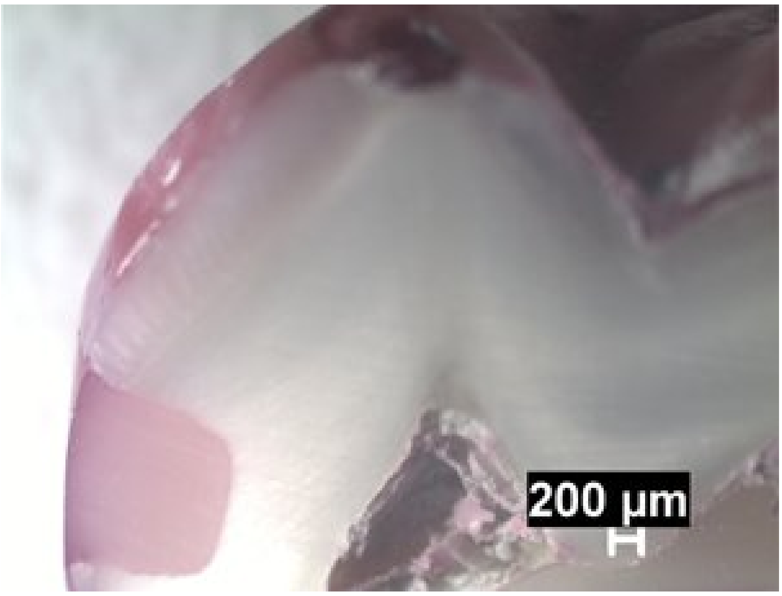

Figure 2. Stereomicroscopic images group 6 showing microleakage pattern between teeth and restoration at ×20 magnification.

DISCUSSION

This study confirmed that using laser irradiation in several power levels and frequencies compared to the conventional bur treatment may have an advantage in decreasing the microleakage level of compomer restorations in primary molar Class V cavities.

Since the compomers are being used in dentistry[4], the clinical failures due to the microleakage are considered to be a common problem in this field.[25] If microleakage occurs, bacteria will grow beneath the restoration which may cause pulpal response, postoperative sensitivity and recurrent caries.[26,27] Compomers are capable of buffering aqueous acid solutions, raising their pH from acidic to nearly neutral, which together with fluoride release provides some protection against secondary caries.[6] However, microleakage problems can also be achieved due to difficulties on application of adhesive materials without contamination into the cavities.[4,6] Due to these drawbacks, the best procedure for the excellent restoration has been the goal of research in the last decades. Especially in recent years, research has focused on new methods of cavity preparation. Sono abrasive, air abrasive and preparation by laser have been developed as alternatives to preparation by bur. [27,28]

Still, in *in vitro* models, qualitative microleakage assessments are interpreted as valuable tools for evaluating the new materials and technologies. The dye penetration technique is the generally preferred method because it is easy, cheap, and non-toxic.[7,28] Gonzales et al.[29] showed that the best demonstrative dye for the microleakage was 0.5 % basic fuchsine. In this study, the dye penetration method with 0.5 % basic fuchsine was applied and samples were immersed in fuchsine solution for 24 hours. Microleakage scores were evaluated by two examiners. Thus we used this model to predict the clinical performance of the compomer restorations after treating with laser or bur methods. Moreover, using thermocycling may also mimic the oral environment conditions to improve the validity of the microleakage scores.[30] The leakage after thermocycling has been linked with the marginal staining, postoperative sensitivity, and secondary caries.[10,30] Investigators also recommended administering the 200-1000 thermal cycles between the 5-55^{0}C as an acceptable way to simulate the oral conditions.[28] In the present study, we also used 500 times at 5± 2°C to 55±2°C; dwell time 15 s and transfer time 10 s to make standartization for the microleakage procedures.

In primary molar teeth treatments, it can be observed that compomers are the most preferable materials because of their main advantages.[24] Moreover, from the literature, the microleakage studies have focused on the permanent teeth in *in vitro* models.[6,8,25] Little data have been published about the primary molar teeth in compomer leakage studies.[31] In this study, primary teeth were used for this reason. In primary molars, the pretreatment of enamel without phosphoric acid seems acceptable to obtain better retention capacity by use of a one-bottle adhesive only.[32] Cecilia et al.[33] compared microtensile bond strength of etch and rinse (Prime&Bond NT) and self etch (Adper Prompt-L-Pop) to primary and permanent teeth. In their study, composite resin and polyacid modified composite resin were used. They found that Prime&Bond NT exhibited better adhesion of both composite resin and polyacid modified composite resin than Adper Prompt-L-Pop. Since this study was performed with human primary teeth, in parallel with previous studies, adhesion features were determined successfully. Furthermore, one should take into account that one adhesive system (Prime&Bond NT) and one compomer (Dyract® eXtra) were used in this study. Besides the common evident factor that influences the leakage is the restorative material and adhesive nature[4], laser treatment could have beneficial effects on microleakage scores as consistent with previous studies.[17,21,28] In this study, the surface energy surface and the presence of moisture may provide optimal wetting by hydrophilic bonding agents as previously described.[10] In addition, the Er,Cr:YSGG laser contributes to the excellent adhesion features of the between the restorative materials and lased surface.[10,22] This is in accordance with the previous study, which confirmed that using 2W laser with 20 Hz may have a potential advantage for decreasing the microleakage of fissure sealants.[28]

Effective ablation of dental hard tissues by means of Er,Cr:YSGG laser systems has been reported.[22] This laser system uses a pulsed irradiation mode, and the energy is delivered through a proprietary flexible fibre to a handpiece, to which sapphire tips of 0.4 or 0.6-mm diameter are attached. During irradiation and between pulses, the tissues are bathed in a water mist spray, and this spray is employed for most soft tissue surgical procedures, as well as when cutting enamel, dentine and bone. When dental hard tissues are lased by the Er,Cr:YSGG laser accompanied with a water spray, a net negative thermal effect occurs, with the tissues becoming cooler. Use of the water mist spray also increases the cutting efficiency of the laser. Histological studies have reported minimal pulpal inflammatory responses when hard tissues are treated by the Er,Cr:YSGG laser with water mist spray, with effective cutting and no adverse clinical side effects.[34]

Many studies have examined the effect of both Er, Cr: YSGG[22,35,] and Er: YAG laser[17,36-40] and bur preperation on microleakage.[18] Some of these studies found that lasers exhibited equal or better microleakage scores than bur[35-37], and the other studies found lasers exhibited worse microleakage scores than bur.[38-40]

Prime&Bond NT contains nanoscale fillers in its formulation, and thus one single coat of application is sufficient. The nanofiller strengthens the hybrid layer and the adhesive layer, making these interfaces more compatible with both the tooth structure (containing inorganic calcium apatite) and the compomer material (containing inorganic glass filler). Besides, the viscosity of Prime&Bond NT has not increased significantly, allowing deep penetration of the bonding resin into the dentin.[10,41,42] Rosa and Perdigao[43] claimed that compomers bonded with Prime&Bond NT, without any prior etching, yielded the highest bond strength. Since Prime&Bond NT can be used with or without prior acid-etching[10,41,42,44,45], it was applied to the cavity wall without a separate etching step in the present study.

During preperation by bur, increases in temperature and pressure have occured because of vibration and friction. Due to the fact that increasing the temperature and cell differentiation can occur in the pulp, pain can also begin.[46] In addition, discomfort could result from pressure and voice.[47] Moreover; microcracks and smear layer were showed in SEM studies. Furthermore, unnecessary sound tissues can be removed with bur.[48] Various microorganisms survive in the oral cavity. Several studies showed that even after cavity preperation, some microorganisms should survive. Microorganisms inhabiting the deeper layer cannot be eliminated by surface disinfectant.[49,50] It is known that the smear layer, which occurs after the cavity preperation with bur, is very important for adhesion and microleakage. Various studies showed that thick and compact smear layer occur by bur, although no smear layer was seen in laser preperation. The morphological structures of prepared and etched surfaces by laser have attracted the interest of many researchers.[51-53]

Lin et al.[54] used SEM to evaluate surfaces prepared with the Er,Cr:YSGG laser (6 W, 20 Hz, air and water cooling) or a bur, and found that there was a smear layer on the surfaces prepared with the bur, so that the prismatic structure of the enamel was not clearly seen, whereas the surfaces prepared with the laser were clear, had no smear layer and had a prismatic structure. Ekworapoj et al.[55] ablated dentin by using Er,Cr:YSGG with different power levels (3, 3.5, 4, 4.5 W , 20 Hz with air and water) and evaluated morphological differences by SEM. They reported that all power levels eliminated the smear layer, peritubular dentine was seen markedly, dentine tubules were opened, and minimum 3,5 power level dentine began melting and became malformated.

Various studies showed that when the cavity gingival wall was located in dentine or cement, the gingival microleakage score was more than that of the occlusal wall,[38,39] although fewer studies showed that there were no statistically differences microleakage levels of gingival and occlusal wall.[52,56]

Khan et al.[37] evaluated the microleakage of premolar and molar teeth restorated with three different restorative materials and prepared by Er:YAG or conventional bur *in vitro*. The results of their study showed that there were no statistically significant differences related with preparation type. Hossain et al.[36] prepared (3x3x2) a cavity on buccal surfaces of human teeth with a non-contact mode Er:YAG laser (enamel; 400 mJ, 15 Hz; dentine 200 mj, 2Hz), on lingual surfaces with bur. They reported that there were no statistically significant differences between lingual or buccal surfaces. Roebuck et al.[21] investigated the effect of power level to microleakage. Class V cavities located on the enamel cement junction on premolar teeth prepared with Er:YAG laser (200 mJ, 240 mJ, 300 mJ, 5 Hz, with air and water) were restored with compomer. They reported that 240 mJ enamel preparation was occured statistically different less microleakage than other power level. However, on dentine, there were no statistically significant differences between the laser or diamond bur. Niu et al.[57] investigated the effect of Er:YAG laser and diamond bur to microleakage on human teeth. They prepared Class V cavities with laser (2W, 10 Hz, with water and air) and bur. There were no statistically significant differences between these groups. Delme et al.[52] investigated the effect of Er:YAG laser and diamond bur to microleakage on human teeth *in vitro*. They prepared Class V cavities 1.5 mm below the enamel cement junction with the laser and bur. They reported no statistically significant differences between groups. In this study, neither tested laser power levels nor frequenices resulted in significant differences regarding microleakage with respect to the laser groups ($p<0.05$). Additionally, in Groups 4 and 6, the lased enamel and dentine test cavities exhibited significantly lower microleakage scores compared to the bur (control) groups. In these gorups (2,5 W 20 Hz and 3W 20 Hz), fewer microleakage characteristics were relatively obtained.

Controversial findings are avaliable in the literature about using the Er: YAG laser technique to reduce microleakage of restorative materials. Such previous studies revealed that the cavities prepared and treated by laser without acid etching would not be sufficient to decrease the microleakage level of restorations.[18,58] However, in contrast with the above studies, lased enamel or dentine surfaces for eliminating the microleakage had been reported as favorable without adversely influencing the marginal integrity of dental restorative materials.[34,58]

Further study is needed to estimate clinical success and to prove these effects and the potential benefits of this laser system and the frequency settings. An *in vitro* study never truly represents the oral environment. Therefore, there is a need for many *in vitro* and clinical studies.

The hypothesis was accepted among the lased cavities as for the inter-group comparisons ($p>0.05$) but also rejected in Groups 4 ($p<0.014$, $p<0.005$) and 6

($p<0.008$, $p<0.008$) as for the intra-group comparisons ($p<0.05$).

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