Original Article

Assessment of Microleakage of Class V Composite Resin Restoration Following Erbium-Doped Yttrium Aluminum Garnet (Er:YAG) Laser Conditioning and Acid Etching with Two Different Bonding Systems

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Abstract:

Introduction: The use of laser for cavity preparation or conditioning of dentin and enamel surfaces as an alternative for dental tissue acid-etch have increased in recent years. The aim of this in vitro study was to compare microleakage at enamel-composite and dentin-composite interfaces following Erbium-Doped Yttrium Aluminum Garnet(Er:YAG) laser conditioning or acid-etching of enamel and dentin, hybridized with different bonding systems.
Methods: Class V cavities were prepared on the lingual and buccal surfaces of 50 recently extracted intact human posterior teeth with occlusal margin in the enamel and gingival margin in the dentin. The cavities were randomly assigned to five groups: group1:conditioned with laser (Energy=120mJ, Frequency=10Hz, Pulse duration=100μs for Enamel and Energy=80mJ, Frequency=10Hz, Pulse duration=100μs for Dentin) + Optibond FL, group2:conditioned with laser + etching with 35% phosphoric acid + Optibond FL, group3:conditioned with laser + Clearfil SE Bond, group 4 (control):acid etched with 35% phosphoric acid + Optibond FL, group 5 (control): Clearfil SE Bond. All cavities were restored using Point 4 composite resin. All samples were stored in distilled water at 37°c for 24 h, then were thermocycled for 500 cycles and immersed in 50% silver nitrate solution for 24 h. The teeth were sectioned bucco-lingually to evaluate the dye penetration. Kruskal-Wallis & Mann-Whitney tests were used for statistical analysis.
Results: In occlusal margins, the least microleakage showed in groups 2, 4 and 5. The maximum microleakage was observed in group 3 (P=0.009). In gingival margins, the least microleakage was recorded in group2, while the most microleakage was found in group 5 (P=0.001). Differences between 5 study groups were statistically significant (P<0.05). The microleakage scores were higher at the gingival margins.
Conclusion: The use of the Er:YAG laser for conditioning with different dentin adhesive systems influenced the marginal sealing of composite resin restorations.
Keywords: Er-YAG Laser; conditioning; resin composite; bonding agent

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Introduction

Despite the recent advances in the formulation of composite resins, shrinkage during polymerization of resin matrix is still a causative factor in the failure of direct resin restoration (1). Therefore the preparation of dental surface in order to create a adequate bond of the resin with enamel and dentin is necessary. According to Buonocuore report, the standard method for enamel surface preparation is the use of acid etching (2). Despite the reliability of adhesion to enamel, bonding to dentin has been considered more difficult and less predictable (3,4,5).

In recent years, the use of laser for cavity preparation as well as for dentinal and enamel surfaces conditioning as an alternative method for acid etching is increasing (6,7). Because of the unique topography created by laser in enamel and dentin, superficial changes created by laser irradiation can have an effect on microleakage of adhesive restoration. Erbium-Doped Yttrium Aluminum Garnet (Er:YAG) laser was one of the first laser to be used in studies for caries removal and cavity preparation, and it can cut dentin and enamel in a more efficacious and efficient way compare to other available lasers (8-10). With the use of this laser, thermal damage to the tooth is reduced, especially when used simultaneously with water spray (11,12). Moreover, cavity preparation via Er:YAG laser (Laser etching) have been proposed as an alternative method for enamel and dentin etching (13-15). This laser has been approved by the US Food and Drug Administration (FDA) for caries removal and cavity preparation in 1997 (16) and it has been proved that this laser is more efficacious in removal of dental tissues compare to other laser systems (17). Rough dentinal surfaces with open dentinal tubules and without any smear layer production have been reported after preparation by laser (18,19).

In addition to this abrasive effect of Er:YAG laser which is accompanied by a preservation of enamel and dentin, this laser can be used to induce changes on dental surfaces which will lead to elimination of acid etching. Several studies have demonstrated that the use of laser for changes on dental surfaces improves the quality of restoration adhesion (20-24).

Information gathered from studies related to the use of Er:YAG laser for dental surfaces conditioning and its effect on microleakage of composite restoration, leaves place to debate. Contradictory results have been reported on the quality of composite restoration margins after laser conditioning, routine acid etching and laser/acid etching (14,18,22-29). For instance, the use of laser for etching before composite restoration has only been recommended by a limited number of studies (22,23, and 30).

Therefore, considering the aforementioned and the increasing use of laser technology in dental treatments in the last decade, this study has the intention, in the frame of an experimental trial, to evaluate the efficiency of laser in the reduction of class V composite microleakage with the using a etch and rinse (3 steps) adhesive and a self-etch (2 steps)adhesive .

Methods

Fifty recently extracted human premolars and molars were collected in 0.2% thymol solution from dental clinics . All teeth were cleaned and stored in distilled water till use . Teeth were randomly divided in 5 groups (n=10).Wedge shape class V cavities on buccal and lingual surfaces (width: 4mm, height: 3mm, depth: 1/5mm) were prepared by high speed (S-Max NSK, Shimohinata, Japan) and cylindrical Diamond Bur (Dentsply, London, England) (Figures 3-5), in a way that occlusal margin was located in enamel and gingival margin in dentin.

In group 1, after cavity preparation, laser was used to condition the surfaces. In enamel laser was applied with 12mJ of energy, a frequency of 10Hz with a pulse of 100 µs (VSP mode) and an irradiation dose or energy density of 18,87J/cm². For dentinal laser was applied with 80mJ of energy, a frequency of 10Hz with a pulse of 100 µs and an irradiation dose or energy density of 12,58J/cm². To simulate clinical conditions the laser was used without contact of the handpiece tip with the cavity surfaces and at a distance of 0.5 mm from the surface. Then Optibond FL (Kerr, Salerno, Italia) bonding system was used according to manufacturer’s instructions and then light cured for 20 seconds (Coltolux50, Coltene/Whaledent Inc, Cuyahoga fall,USA).

In group 2, laser was used to condition surfaces with the same parameters as for group 1. In this group acid phosphoric 35% (Ultra-Etch Ultradent Products Inc, South Jordan, USA) was used prior to application of Optibond FL in addition to laser etching.

In group 3 also laser was used with the same aforementioned parameters for surface conditioning. After that Clearfil SE Bond (Kurary Medical Inc, Tokyo, Japan) which is a two-step self-etch bonding was used according to the manufacturer's instructions and then light cured for 20 seconds.

For group 4, first, acid phosphoric was used in the cavity, in such a way that enamel parts were etched for 20 seconds and dentin parts for maximum 15 seconds. Then the samples were washed with water for 15 seconds, after that drying was for 3 seconds (not in a way to completely dry the surface). After that, Optibond FL bonding systems was used as .for groups 1 and 2.

In group 5, only Clearfil SE Bond was used as indicated by the manufacturer's instructions. The bonding method was similar to group 3 (Figure 1).

After the application of adhesive agents, the cavities of all groups were incrementally restored with Point 4 composite resin (Kerr, Salerno, Italia) in 3 increments. The first against the the occlusal wall and the second against the gingival wall, (In an oblique way) .The final increment was placed flush with the contour of the tooth with a mylar strip. Each layer was light cured for 40 seconds.

The specimens were stored in the incubator (Behdad, Tehran, Iran) for 24 hours at 37°c without vibration. Then the samples were polished with the composite polish bur and Sof-lex discs (3M ESPE, USA) following manufacturer instraction. All the teeth were subjected to 500 thermal cycles between 5 and 55°c with a dwell time of 3 sec (Vafay Industrial Agenty-Iran). The specimens were coated with 2 layers of nail varnish within 1 mm of the tooth- restoration margin after the apexes were sealed with molding wax. After sealing, the samples were immersed in a 50% silver nitrate solution (Merck, Darmstadt, Germany) for 24 hours. After rinsing, the samples were mounted in a self hardening acrylic.

Mounted samples were sectioned longitudinally in buccolingual direction with low speed diamond disk (D&Z Germany). Slices were evaluated by 3 persons unaware of the cavity preparation tools and adhesive agents used, in a double blind design. Microleakages were assessed by the stereomicroscope (MGC-IO, Russia) at 18 X. magnification. Scoring was done according following criteria:

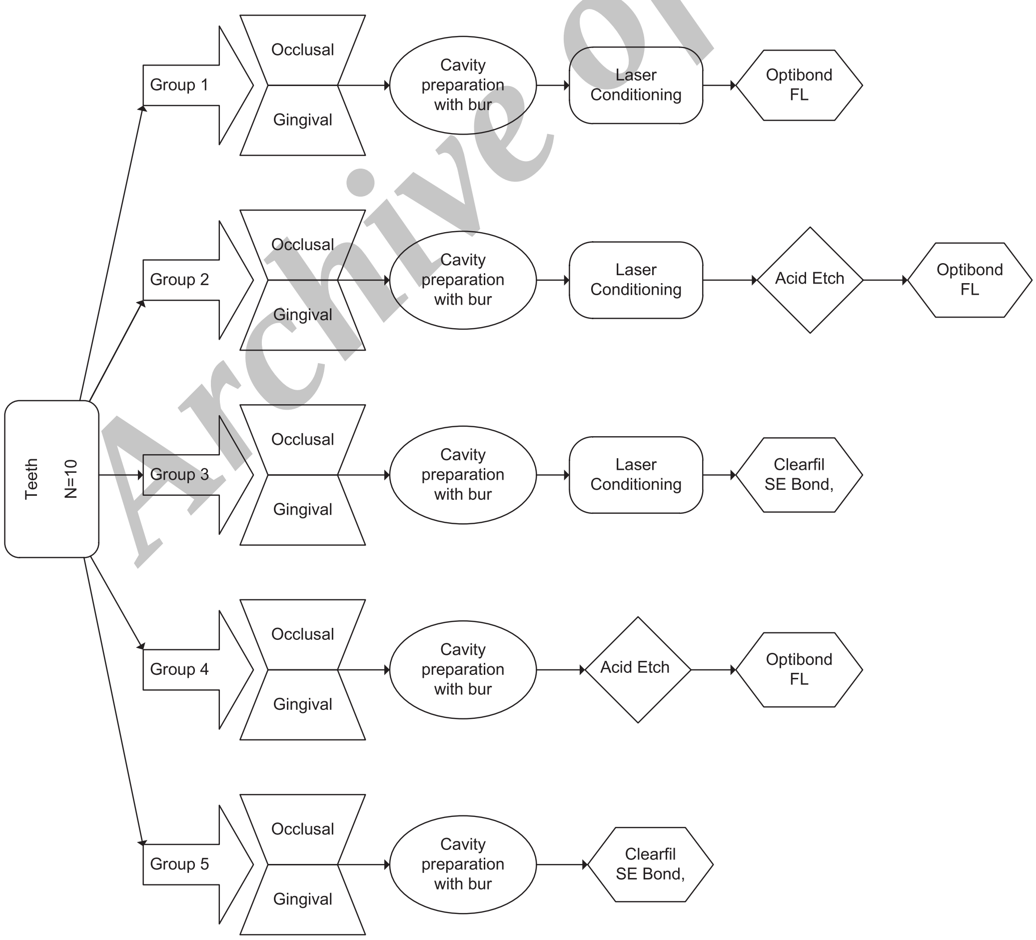

Figure 1. Comparisons between groups

- 0: No dye penetration (Figure 2)
- 1: Dye penetration to less than half of the cavity (Figure 3)
- 2: Dye penetration to more than half the cavity depth (Figure 4)
- 3: Dye penetration to the cavity depth and dentinal tubules toward pulp (Figure 5)

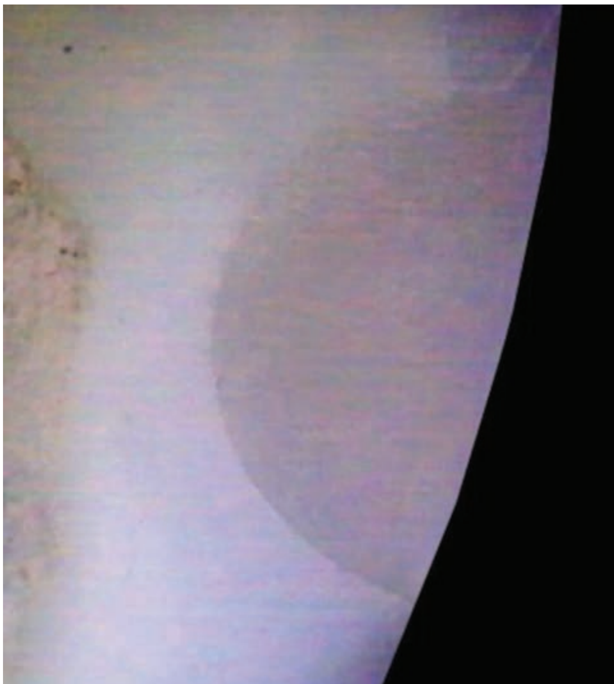

Figure 2. Grade 0

Figure 3. Grade 1

The data was analyzed with statistical tests Kruskal-Wallis and Mann-Whitney.

Results

The statistical analysis of the different groups

Figure 4. Grade 2

Figure 5. Grade 3

showed that there was a significant difference in the amount of microleakage between the groups. In the occlusal margins of cavities of the different groups the *P*=0.000 and in the gingival margins of cavities of the different groups *P*=0.002. Therefor the results obtained from this study show that the different modalities used can change the microleakage in the occlusal margins as well as in the gingival margins of class V composite restorations, with a significant statistical difference (Tables 1,2 and Figure 6).

The greater mean of microleakage in the occlusal margin was found in group 3 (laser and SE bond). Groups 2,4,5 exhibited less microleakage than the other groups. The greater mean of microleakage in the gingival margin belonged to group 5, in which group only SE bond was used as a bonding agent. The lower mean was related to group 2 (laser and acid etching, and then Optibond FL).

Table 1. Statistical analysis of microlekage score of 5 groups in the occlusal margin

Groups	2	3	4	5
1	*P*=0.317	*P*=0.035*	*P*=0.317	*P*=0.317
2		*P*=0.009*	*P*=1.000	*P*=1.000
3			*P*=0.009*	*P*=0.009*
4				*P*=1.000

*Statistically significant

Table 2. Statistical analysis of microlekage score of 5 groups in the gingival margin

Groups	2	3	4	5
1	*P*=0.313	*P*=0.028*	*P*=0.047*	*P*=0.004*
2		*P*=0.009*	*P*=0.011*	*P*=0.001*
3			*P*=0.755	*P*=0.532
4				*P*=0.359

*Statistically significant

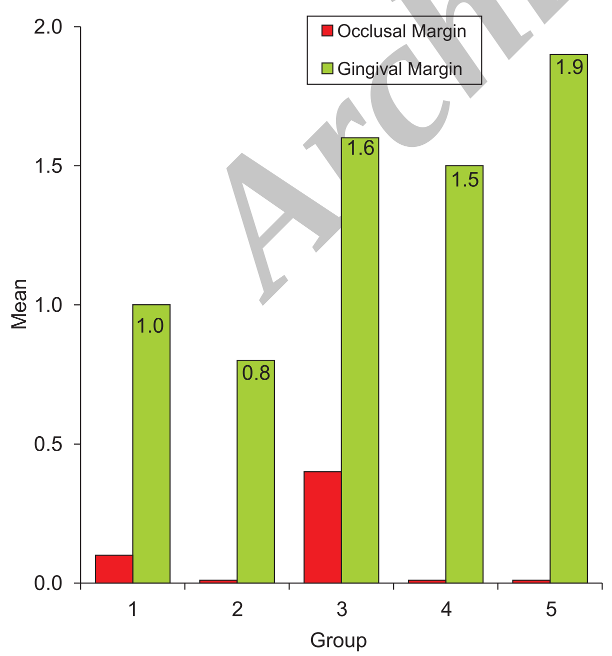

Figure 6. Mean microleakage scores in the different study groups for occlusal and gingival margins

The statistical analysis, considering the amount of P in occlusal and gingival margins showed that in at least two of these 5 groups there is a significant statistical difference concerning two variables (conditioning method and type of bonding). Therefor to determinate this issue, the 5 groups were compared 2 by 2 with the use of the Mann-Whitney test, and the results obtained are as follow:

There was a significant difference only between groups 1&3, 2&3, 3&4, 3&5 (table 1). In summary microleakage in the occlusal margin in group 3 had a significant statistical difference with all the other groups. As we said the group 3 had the greater mean of microleakage among the studied groups (Table 1 and Figure 7).

The microleakage grade in the gingival margin had a significant difference between groups 1&3, 1&4, 1&5, 2&3, 2&4, 2&5 (Table 2 and Figure 8).

In the separate analysis of these groups, there was a significant statistical difference in the microleakage

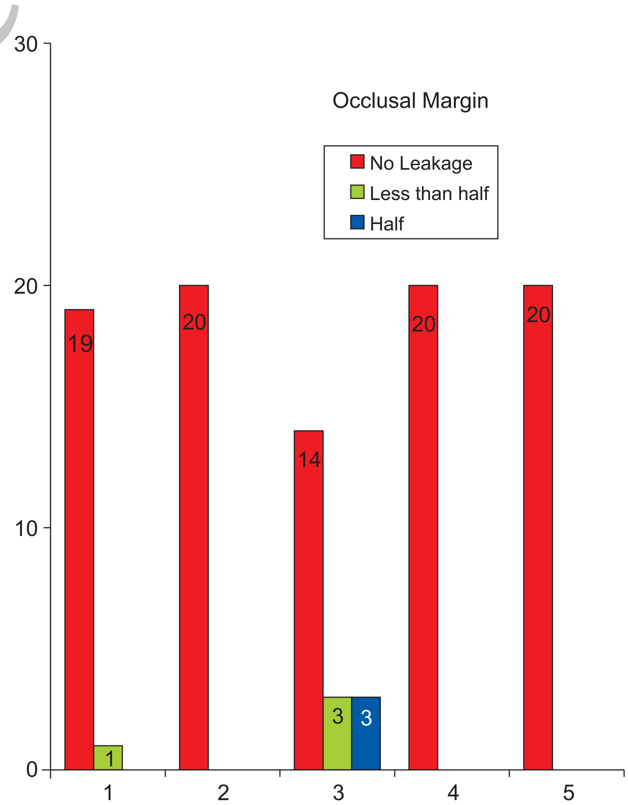

Figure 7. Microleakage score means of occlusal margin

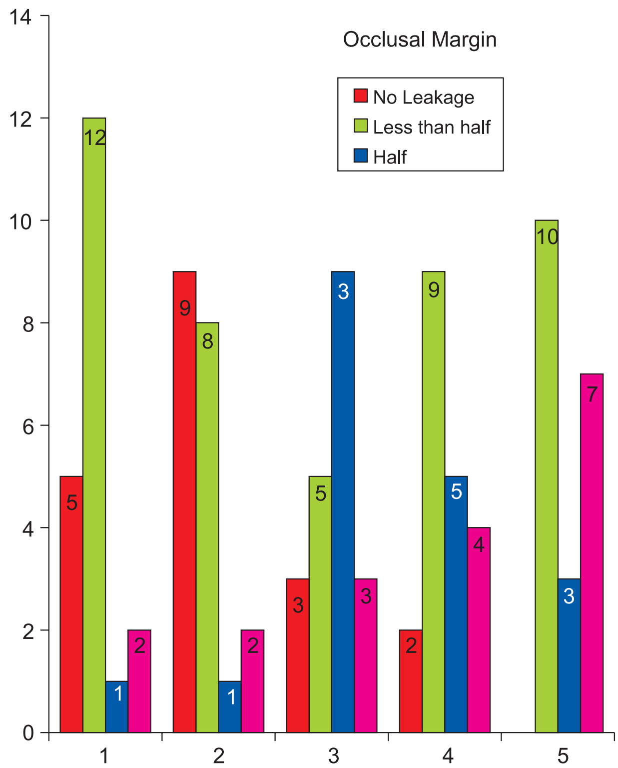

Figure 8. Microleakage score means of gingival margin

grade between the occlusal and gingival margins of all groups. Also, the mean microleakage degree in the occlusal margin was lower.

Discussion

After the execution of the different work stages and the obtaining of data, the main question was that did the seal created by laser etching was as efficacious as the acid one? The results of other studies about this matter are contradictory and we decided to reevaluate this method.

The results of our study showed that in occlusal margin (enamel) when laser was applied for surface conditioning, with SE Bond (Comparison of groups 3 and 5) the amount of microleakage was higher, which showed a significant statistical difference (P=0.009). But about Optibond FL (Comparison of groups 2 and 4) the amount of microleakage didn't change and there wasn't a significant statistical difference. Also about Optibond FL, when instead of acid only laser was used for surface conditioning (Comparison of groups 1 and 4), again the microleakage was high, but the difference wasn't statistically significant (P=0.317).

In the gingival margin (dentinal) when laser was used for surface conditioning, with SE Bond (Comparison of groups 3 and 5) the amount of microleakage was lower, but the difference wasn't statistically significant. For Optibond FL (Comparison of groups 2 and 4) the amount of microleakage was lower and the difference was statistically significant (P=0.011). Also for Optibond FL, when instead of acid only laser was used for surface conditioning (Comparison of groups 1 and 4), again the microleakage was lower and the difference was statistically significant (P=0.047).

Therefor results showed that the use of laser for surface conditioning of occlusal margins (enamel) increased the microleakage (especially about SE Bond). But in gingival margins (dentinal) the use of laser decreased the amount of microleakage (especially about Optibond FL).

But the results of Armengol et al. demonstrated that acid etching is more efficient in the reduction of microleakage compare to Er:YAG laser. Armengol stated that in the enamel margins the difference was significant, but in the dentinal margins it was not (25).

Krmek et al. affirmed that the simultaneous use of laser for cavity ablation and acid phosphoric for surface conditioning was the best method microleakage reduction and that each one has its own advantages (32):

1) Laser irradiation produces a rough, coarse, harsh and non uniform surface without any smear layer (33,34).
2) Acid phosphoric widens the dentinal tubules and demineralized surfaces which in consequence render the collagen fibers visible (35).

Furthermore, our study demonstrated that most of the microleakage are related to when the cavity was prepared by laser but acid etch wasn't performed, and in the cavities prepared by the conventional methods and acid etch, a medium amount of microleakage was observed.

Recently numerous studies have presented similar observations regarding the concern of microleakage following laser irradiation:

Yazici et al. showed that the grade of microleakage in the interface of resin and tooth was definitively lower in all groups that were conditioned acid etch (36).

Borsatto et al. obtained the lowest amount of marginal seal when the pits and fissures where conditioned by laser Er:YAG. The surface conditioning with Er:YAG laser alone resulted in the higher amount of microleakage (37).

Ceballos et al. reached similar conclusions, that laser irradiation was not an effective and valid modality in replacement of acid etch for resin material bonding (22).

Another researcher stated that laser irradiation alone can't be an alternative for acid etching. Acid etch after cavity preparation with Erbium, Chromium doped Yttrium Scandium Gallium Garnet (Er:Cr:YSCG) laser was recommended, which is the same way used to obtain the best sealing after cavity preparation in the standard method. He affirmed that laser irradiation seems to result in morphological changes like tiny cracks, pits and fissures which are responsible for the increase of microleakage (6).

In the present study, the degree of microleakage between occlusal and gingival margins had a significant difference in the other groups, for which the mean degree of microleakage of occlusal margins was lower, which correspond to a higher mean microleakage in gingival margins. This result is similar to the ones obtain in previous studies (25,32,38). For instance Armengol claimed that in all cavities in enamel margins the amount of microleakage was lower than for dentinal margins (either in cavities which surfaces had been prepared or in cavities where surfaces haven't been prepared) (25).

Delme et al. declared the same results for the groups which underwent acid etching, but for the groups which underwent laser etching with Er:YAG after cavity preparation and did not had acid etch, they reported that there was no significant statistical difference between them in terms of microleakage (39).

In the present study, for the groups where laser was not used to condition the surfaces (groups 4 and 5) there wasn't a significant statistical difference in the amount of microleakage between the two different bonding systems (either in occlusal margins or in gingival ones). But when laser was used for surface conditioning (groups 2 and 3) a very significant statistical difference was found in the amount of microleakage between the two different bonding systems and for both margins (*P*=0.009). This means that in the surface conditioning with Er:YAG laser, the bonding agent Optibond FL shows a very lower amount of microleakage.

In most of the similar studies, one bonding system was used, but in a limited number of studies, several types of bonding agent were used (14,22,24 and 39). They all acknowledged the fact that the difference in microleakage between the different bonding systems was not statistically significant. For example, Delme et al. didn't find any significant statistical difference in the changes of the amount of microleakage between 4 types of bonding systems (39).

Conclusion

Based on the results of this study, the use of laser for surface conditioning in the occlusal margin increases the amount of microleakage, but decreases it in the gingival margin.

In the different groups, the microleakage observed was pronouncedly more in the gingival margins compared to the occlusal ones.

Also, in the groups in which laser was used to condition the surfaces (groups 2 and 3), the bonding agent Optibond FL showed less microleakage compare to Clearfil SE Bond, with a significant statistical difference (*P*=0.009). The reason for this is perhaps the surface changes due to laser irradiation, thus the SE Bond which is designed for smear layers, is not able to build convenient bonds in this changed surface anymore. But in the groups where laser was not used (groups 4 and 5), between those two bonding agents, a significant difference wasn't seen.

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