RAPID POLYMERIZATION AND ETCHING PROCEDURE EFFECT ON MICROLEAKAGE OF CLASS V RESTORATIONS

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ABSTRACT

Background and Aim: This study aimed to investigate the effect of the rapid polymerization and etching procedure on microleakage scores of Class V restorations.

Materials and Methods: Class V cavities were uniformly prepared by one operator in 60 bovine incisors. The specimens were randomly divided into six groups and restored as follows: Group 1: Selective enamel etching (SEE) + sixth-generation adhesive system (AS) + composite resin (CR) polymerized at 3200 mW/cm2 for 6 s. Group 2: SEE + sixth-generation AS + CR polymerized at 1000 mW/cm2 for 20 s. Group 3: No etching (NE) + sixth-generation AS + CR polymerized at 1000 mW/cm2 for 20 s. Group 4: NE + sixth-generation AS + CR polymerized at 3200 mW/cm2 for 6 s. Group 5: Total etching (TE) + fifth-generation AS + CR polymerized at 3200 mW/cm2 for 6 s. Group 6: TE + fifth-generation AS + CR polymerized at 1000 mW/cm2 for 20 s. After the thermal cycling procedure, all specimens were sectioned and microleakage scores were evaluated by two operators. The data were analyzed using Kruskal-Wallis and Mann-Whitney U tests ($p = 0.05$).

Results: Gingival microleakage scores were found higher than incisal microleakage scores ($p<0.05$). Results of the microleakage test revealed that different cavity conditioning methods, duration and power density of the light polymerization procedure significantly affected the microleakage rates at the incisal margins ($p<0.05$).

Conclusion: SEE with the sixth-generation AS reduced microleakage. Rapid polymerization procedures can be performed for small Class V cavities using the etch-and-rinse system and SEE procedure.

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Keywords: Adhesive Systems, Class V Restoration, Microleakage, Selective Enamel Etching.

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HIZLI POLİMERİZASYON VE ASİTLEME PROSEDÜRLERİNİN SINIF V RESTORASYONLARININ MİKROSIZINTISINA ETKİSİ

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ÖZ

Amaç: Bu çalışma, Sınıf V restorasyonların mikrosızıntı skorları üzerine hızlı polimerizasyon ve asitleme prosedürlerinin etkisini araştırmayı amaçladı.

Gereç ve Yöntem: Sınıf V kaviteler bir klinisyen tarafından atmış sığır kesici dişine aynı şekilde hazırlandı. Örnekler rastgele altı gruba ayrıldı ve şu şekilde restore edildi: Grup 1: Selektif mine asitlemesi + 6. jenerasyon adeziv sistem + 3200mW/cm2 güçte 6 saniye polimerize edilen kompozit rezin. Grup 2: Selektif mine asitlemesi + 6. jenerasyon adeziv sistem + 1000mW/cm2 güçte 20sn polimerize edilen kompozit rezin. Grup 3: Asitleme yok + 6. jenerasyon adeziv sistem + 1000mW/cm2 güçte 20sn polimerize edilen kompozit rezin. Grup 4: Asitleme yok + 6. jenerasyon adeziv sistem + 3200mW/cm2 güçte 6sn polimerize edilen kompozit rezin. Grup 5: Total asitleme + 5. jenerasyon adeziv sistem + 3200mW/cm2 güçte 6sn polimerize edilen kompozit rezin. Grup 6: Total asitleme + 5. jenerasyon adeziv sistem + 10000mW/cm2 güçte 20sn polimerize edilen kompozit rezin. Termal yaşlandırma sonrasında bütün örnekler ortadan ikiye bölündü ve mikrosızıntı değerleri iki araştırmacı tarafından değerlendirildi. Veriler Kruskal Wallis ve Mann Whitney U testleri kullanılarak SPSS 16.0 bilgisayar programında analiz edildi ($p= 0.05$).

Bulgular: Gingival mikrosızıntı değerleri insizal mikrosızıntı değerlerinden daha fazla bulundu ($p<0.05$). Mikrosızıntı testi sonuçları, farklı kavite şartlandırma metotları ile ışıkla polimerizasyonda ışık gücü ve süresinin insizal kenarlarda mikrosızıntı skorlarını anlamlı derecede etkilediğini ortaya koydu ($p<0.05$).

Sonuç: Altıncı jenerasyon adeziv sistem kullanıldığında selektif mine asitleme prosedürü mikrosızıntıyı azalttı. Hızlı polimerizasyon prosedürü küçük kavitelerde 'Asitle ve Yıka' grubu adeziv sistemlerle ve selektif mine asitlemesi prosedürü ile birlikte kullanılabilir.

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Anahtar Kelimeler: Adeziv Sistemler, Sınıf V Restorasyon, Mikrosızıntı, Selektif Mine Asitleme

Sorumlu Yazar
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INTRODUCTION

The great demand for esthetic restorations has led to an increasing use of composite resins with the advantages of easy handling, excellent optical characteristics, biocompatibility, and good mechanical properties. However, the main shortcomings of composite resins are marginal gap formation and microleakage due to polymerization shrinkage.[1, 2] Polymerization shrinkage occurs as a result of conversion of organic matrix monomers into a polymer and causes tension at the restoration-tooth interface [2]. The shrinkage stress of composite materials depends on many factors, such as the type of organic matrix, type of inorganic filler content, degree of conversion rate, and modulus of elasticity. [3, 4]

Many methods have been utilized to reduce shrinkage stress; [5] One of these methods is using a slower photo activation protocol and extending the pre-gel phase, in which the resin can flow and relieve the tension. [6, 7] However, it is claimed that the photo activation of composite resins at an acceptable degree of conversion is possible in a shorter time by using their high-energy intensity curing units. Polymerizing composite resin materials with high intensity curing units also results in improved mechanical properties.[8-10] The rapid polymerization procedure with high- energy density curing devices has additional benefits in terms of reducing errors related to the positioning of the light guide tip on the restoration. This procedure also leads to time saving in restorative applications.[11] However, polymerizing composite resins with high intensity curing devices raises concerns about microleakage in cavities with high C-factor.

Different etching and adhesive techniques can be used for direct composite restorations. Moreover, it is reported in the literature that adhesive procedures directly affect the microleakage of restorations.[12, 13] For this reason, different adhesive application techniques with rapid or normal polymerization modes exhibit varying microleakage rates.

This study aimed to investigate the effect of the rapid polymerization procedure and different etching methods on the microleakage of Class V restorations. The following two hypotheses were tested: "Rapidly polymerized groups have higher microleakage scores" (H_1) and "Restorations performed using different etching procedures have similar microleakage scores in conventionally polymerized groups" (H_2).

MATERIALS AND METHODS

Sixty freshly extracted bovine incisors were obtained for this study and stored in physiologic saline solution at room temperature for less than three months. After surface debridement, standardized Class V cavities (4 mm wide, 2 mm high and 2 mm deep) were prepared on the buccal surfaces of each tooth. The incisal and gingival margins were placed on enamel. The teeth were randomly divided into six groups (n = 10) according to the adhesive procedure and light curing duration. The restorative materials used in the study were listed in Table 1.

Group 1

After cavity preparation, the enamel was selectively etched for 20 seconds with 37% phosphoric acid gel, rinsed, and dried (Condac 37, FGM Products, Brazil). The sixth-generation adhesive system (FL Bond II, Shofu Inc., Japan) was applied according to the manufacturer's instructions and polymerized for 10 s with a LED light-curing device (Valo Cordless, Ultradent, USA) at a power density of 1000 mW/cm^2. The teeth were restored using nano-hybrid composite resin (Beautifil II, Shofu Inc., Japan) and light-cured for 6 s with the same light-curing device at a power density of 3200 mW/cm^2.

Group 2

The enamel was selectively etched for 20 s with 37% phosphoric acid gel, rinsed, and dried (Condac 37, FGM Products, Brazil). The sixth-generation adhesive system (FL Bond II, Shofu Inc., Japan) was applied according to the manufacturer's instructions and polymerized for 10 s with a LED light-curing device (Valo Cordless, Ultradent, USA) at a power density of 1000 mW/cm^2. The teeth were restored using nano-hybrid composite resin (Beautifil II, Shofu Inc., Japan) and light-cured for 20 s with the same light-curing device at a power density of 1000 mW/cm^2.

Group 3

The sixth-generation adhesive system (FL Bond II, Shofu Inc., Japan) was applied according to the manufacturer's instructions and polymerized for 10 s with a LED light-curing device (Valo Cordless, Ultradent, USA) at a power density of 1000 mW/cm^2. The teeth were restored with nano-hybrid composite resin and light-cured for 20 s with the same light-curing device at a power density of 1000 mW/cm^2.

Table 1. The restorative materials used in the study

Material	Type	Composition	Lot Number
Beautifil II (Shofu Inc., Japan)	Nano-hybride composite	S-PRG fillers (68.6% by volume), Bis-GMA (Bisphenol a-glycidyl methacrylate), TEGDMA (Triethylene glycol dimethacrylate).	091401
Prime&Bond NT (Dentsply, Germany)	5th generation total-etch adhesive system	PENTA (dipentaerythritol penta acrylate monophosphate), Di- and trimethacrylate resins, Amorphous Silicon Dioxide Nanofillers, Cetylamine hydrofluoride, Photoinitiators, Stabilizers, Acetone.	1711001166
FL-Bond II (Shofu Inc., Japan)	6th generation self-etch adhesive system	**Primer:** Water, Carboxylic acid monomer, Ethanol, Phosphoric acid monomer, Initiator **Bonding Agent:** S-PRG filler based on fluoroboroaluminosilicate glass, UDMA (Urethane dimethacrylate), TEGDMA, 2-HEMA (2-Hydroxyethyl methacrylate), Initiator	011401

Group 4

The sixth-generation adhesive system (FL Bond II, Shofu Inc., Japan) was applied according to the manufacturer's instructions and polymerized for 10 s with a LED light-curing device (Valo Cordless, Ultradent, USA) at a power density of 1000 mW/cm^2. The teeth were restored using nano-hybrid composite resin and light-cured for 6 s with the same device at a power density of 3200 mW/cm^2.

Group 5

The enamel and dentin were totally etched with 37% phosphoric acid gel for 20 s, and then rinsed and dried properly. The fifth-generation adhesive system was applied according to the manufacturer's instructions and polymerized for 10 s with a LED light-curing device (Valo Cordless, Ultradent, USA) at a power density of 1000 mW/cm^2. The teeth were restored using nano-hybrid composite resin and light-cured for 6 s with the same light-curing device at a power density of 3200 mW/cm^2.

Group 6

The enamel and dentin were totally etched with 37% phosphoric acid gel for 20 s, rinsed, and dried properly. The fifth-generation adhesive system was applied according to the manufacturer's instructions and polymerized for 10 s with a LED light-curing device (Valo Cordless, Ultradent, USA) at a power density of 1000 mW/cm^2. The teeth were restored with nano-hybrid composite resin and light-cured for 20s with the same light-curing device at a power density of 1000 mW/cm^2.

The finishing and polishing procedures of the restorations were performed with aluminum oxide polishing discs (Sof-Lex, 3M ESPE, USA), and the specimens were stored in distilled water at 37°C for 24 h. Then, all specimens were thermocycled 5000 times at +5°C – +55°C water baths with a dwell time of 30 s and transfer time of 3 s. The specimens were prepared for dye penetration as follows: The apexes of all teeth were sealed with flowable composite resin, and two layers of nail varnish were applied to all external surfaces up to 1 mm from the restoration margins. The specimens were placed in 2% methylene blue solution for 24 h. After the specimens were rinsed under running tap water, they were sectioned into two halves vertically in the bucco-lingual direction from the middle of the restorations using a water coolant cutting machine (Microcut, Metkon, Turkey).

All sections were evaluated under a stereomicroscope (Zeiss OPMI Pico Tube f170, Carl Zeiss, Germany) at x40 magnification according to the following standards:

0. No dye penetration
1. Dye penetration along the gingival or occlusal wall to less than half of the cavity depth
2. Dye penetration along the gingival or occlusal wall to more than half of the cavity depth, but not extending onto the axial wall

3. Dye penetration along the gingival or occlusal wall to the full cavity depth and extending onto the axial wall

The data were analyzed using Kruskal-Wallis and Mann-Whitney U tests and SPSS V16.0 computer software. The Bonferroni correction was applied to avoid increasing the "Type I Error" level (p= 0.0033).

RESULTS

The results of the microleakage test revealed that different cavity conditioning methods and the duration and power density of the light polymerization procedure significantly affected the microleakage rates at the incisal margins *(*p= 0.001), but not at the gingival margins. More microleakage was detected at the gingival margins of the specimens (Figure 1). The microleakage scores of the groups are shown in Figure 2.

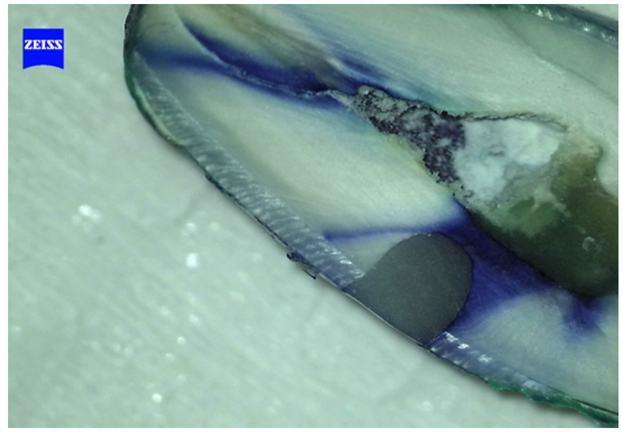

Figure 1. A higher degree of microleakage at the gingival margins

Incisal microleakage scores

Concerning the incisal microleakage scores, Group 1 had significantly lower microleakage than Group 4 (p= 0.002 < 0.0033). The total-etch and 20 s-polymerized group (Group 6) had significantly lower microleakage than Group 4 (p= .000 < 0.0033) and Group 3 (p= 0.002 < 0.0033). The microleakage scores of the total-etch groups (Group 5 and 6) and selective- etch groups (Group 1 and 2) were found similar (p > 0.05). The total-etch 6 s-polymerized group (Group 5) had similar results to Group 3 (p= 0.571 > 0.0033) and Group 4 (p= 0.188 > 0.0033).

Gingival microleakage scores

According to the pairwise comparisons, there were no statistically significant differences between the six groups in terms of gingival microleakage scores (p> 0.0033).

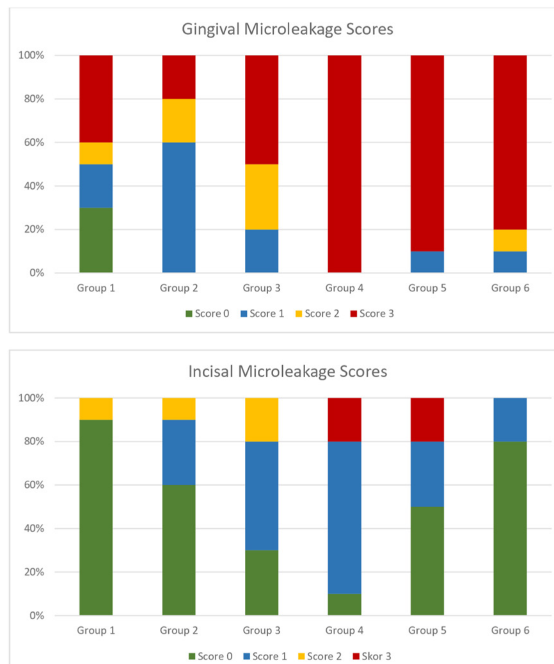

Figure 2. Microleakage scores of the groups

DISCUSSION

As a result of increased esthetic demands of the dental patients, composite resin materials are now often used by dentists in Class V restorations. The margins of this restorations are usually located in the dentin. For the reasons given in the introduction section, in this study, Class V cavities were prepared and restored. The main problem in Class V restorations is microleakage at the gingival margins especially located in the dentin. [14, 15] Many studies report that microleakage is higher at the gingival margin, ending in dentin.[14-16] However, there are also studies that show no difference in the microleakage values between the gingival and incisal margins.[17, 18] Despite the gingival margins being located in enamel in this study, the microleakage scores of the gingival margins were found to be higher compared to the incisal margins. This finding can be related to the decreased enamel thickness through the gingival junction.

Microleakage is one of the most important factor that directly affect the longevity of the restoration.[19] The chemical structure of the monomer, light intensity, temperature, and photo initiator type and concentration can affect microleakage and the degree of conversion of composite resins.[20] The microleakage test has been widely used for evaluating the marginal and internal adaptation of restorative materials.[19] For evaluating the adaptation of the restorative materials to the cavity walls, the dye penetration method is frequently and widely employed because it is simple, comparable, and quantitative. [21] To observe the long term effects of thermal stresses on the marginal integrity, the specimens are subjected to a large number of thermocycles.

According to the findings of this study, Group 1 and Group 6 had better results in terms of microleakage at the incisal margins. The poor results of Group 4 for the gingival margin were similar to those of the other groups. In addition, the microleakage scores of Group 4 at the incisal margin were similar to those of Groups 2, 3 and 5. Therefore, it was considered that rapid polymerization did not significantly affect the microleakage scores; thus, H_1 was rejected.

There are different findings in the literature concerning the effect of LED light-curing on microleakage of composite resin restorations. Santos et al. reported that the polymerization of composite resins with high power intensity LED curing devices caused poor marginal compatibility and increased microleakage.[22] In contrast, Marghalani reported that light intensity modes had no effect on the microleakage of Class II composite resin restorations.[23] While Yılmaz et al.[24] reported that the microleakage of composite resin restorations can be minimized with the use of high-density led curing units. In another study, Costa Pfeifer et al.[18] reported that the cavity dimensions were effective in the formation of microleakage. The authors noted that while the type of adhesive system did not seem to be an influential factor for small restorations in terms of microleakage, it was important for larger restorations.[18] These findings indicate that in addition to the type of polymerization, cavity dimensions, etching procedure and the adhesive technique used may affect the degree of microleakage at Class V cavities.

The results of this study revealed that Group 1 had lower microleakage scores than Group 4; thus, the selective enamel etching procedure decreased microleakage. Furthermore, the total etched group irradiated at 1000 mW/cm^2 (Group 6) showed better results than both self-etch groups (Group 3 and Group 4). It was observed that the selective enamel-etch and total-etch procedures significantly reduced the microleakage. Considering the significant differences between the study groups, H_2 was rejected.

Due to the advances in dental technology, adhesive concepts are continuously changing. According to the current strategies, adhesive systems are classified as etch-and-rinse, self-etch, and glass-ionomer.[25] In this study, to increase the adhesion of self-etch adhesives to the enamel, the selective enamel etching method was applied. However there are controversies regarding the selective enamel etching techniques in terms of whether they would enhance the bonding quality.[26, 27] According to the occlusal microleakage scores obtained from the current study, the etch–and-rinse adhesive application performed significantly better when coupled with 20 s polymerization, and the results were similar for 6 s polymerization. On the other hand, regarding the gingival microleakage scores, the selective etching group had significantly better results for both 6 s and 20 s polymerization.

CONCLUSION

Within the limitations of this in-vitro study none of the combination of adhesive application and polymerization procedures was able to avoid microleakage. Using the fifth-generation etch–and-rinse system or the sixth-generation self-etch system resulted in similar microleakage scores in Class V cavities. The rapid polymerization of the restorations performed with the sixth-generation adhesive system increased microleakage. Selective enamel etching using the sixth-generation adhesive system reduced the microleakage scores. Based on these results, we conclude that rapid polymerization procedures can be effectively performed for small Class V cavities using etch–and-rinse systems and the selective enamel etching procedure.

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