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EFFECT OF RESIN LINERS ON THE MICROLEAKAGE OF CLASS V DENTAL COMPOSITE RESTORATIONS

EFEITO DO USO DE FORRADORES RESINOSOS SOBRE A MICROINFILTRAÇÃO DE RESTAURAÇÕES CLASSE V EM COMPÓSITO ODONTOLÓGICO

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Purpose: The aim of this study was to evaluate the effect of an adhesive applied in layers of different thickness or in association with a filled adhesive or with a low viscosity composite liner on the microleakage of composite restorations. Methods: Forty bovine incisors were prepared with round cavities (4mm diameter X 2mm depth) on the cementoenamel junction. The teeth were assigned to four groups according to the liner used: 1 (control) – application of 1 layer of the Scotchbond Multi Purpose adhesive system (SBMP); 2 – application of 3 layers of SBMP; 3 – application of 1 layer of SBMP followed by application of one layer of Optibond FL adhesive; 4 – application of one layer of SBMP followed by application of flowable composite Flow-it. All cavities were restored using composite resin Z100. The microleakage test was conducted according to ISO (TR11405). Data were analyzed by Kruskall-Wallis test (a=0.05). Results: Group 4 showed less leakage than Group 1. Groups 2 and 3 showed intermediate values and there were no statistical differences when they were compared to the values of Groups 1 and 4 Conclusion: The use of resin liners with flowable composites can reduce the microleakage of composite restorations.

UNITERMS: Flowable composites; Filled adhesives; Composite restorations; Microleakage.

INTRODUCTION

Composite resins were introduced in Dentistry in the mid-1960s and have undergone developmental improvements in performance characteristics such as esthetics, wear rate, and handling. However, a major disadvantage of composite restorations is their high polymerization shrinkage. In vitro measurements of polymerization shrinkage of composite resins range from 1.9% to 6%[17]. The polymerization shrinkage of composite resins can create contraction forces that may disrupt the bond to cavity walls[9, 10]. The competition between mechanical stress in polymerizing composite resins and the bond of adhesive resins to the restoration walls is one of the main causes of marginal failure and subsequent microleakage observed in composite restorations [6].

Although many new bonding systems have been developed to promote good adhesion between the composite resin and dental substrates, they could not ensure perfect sealing of the composite resin restoration[24, 28]. Of special concern is the seal at the interface between cementum/dentin and the composite resin, because adequate seal is critical at these margins, as demonstrated by other authors [7, 24, 28].

Considering that it is very difficult to ensure good marginal seal, the use of compensatory mechanisms such as flexible intermediate resins has been proposed in order to reduce the potential for marginal gaps[25]. The main purpose is to act as a relatively flexible stress-absorbing layer, or “elastic buffer” between the shrinking composite resin and the rigid substrate. For this purpose, thicker adhesive layers of unfilled adhesives[8], filled adhesives[26], and flowable composites[11] have been proposed. These materials may reduce the high stress induced by rigid composite polymerization shrinkage through a more elastic interface. Ausiello, et al. [3] conducted a research applying 3D finite element analysis and demonstrated that the thicker the adhesive layer, the higher the elastic release effect caused by the stress transformation in adhesive layer deformation with more uniform stress distribution. Choi, et al.[8] demonstrated that the contraction stress generated during the placement of a composite restoration was significantly relieved as the layer thickness of low stiffness adhesive was increased. In addition, the stress was shown to be related to the early microleakage in composite fillings[8]. Kemp-Scholte, Davidson[14] have also shown that thicker adhesive layers were associated with lower interfacial stresses and better preserved marginal adaptation. In this way, filled adhesives have been proposed to increase the thickness of the adhesive layer and to improve the bond strength[16].

Filled adhesives have demonstrated good properties to be used in association with restorative composites[26]. The addition of fillers reduces the shrinkage, permits improved bond strength and adds radiopacity to the adhesive layer (preventing diagnosis problems)[17]. Increased thickness and decreased elastic modulus of adhesive layers are related to a better distribution of stress[26]. These characteristics may improve the quality of the restorations, including reduction of the microleakage levels. The manufacturers of filled bonding agents claim that fillers are incorporated into bonding agents to increase the bond strength by reinforcing the unfilled adhesive resin, a technology derived from the composite resins.

Flowable composites have been indicated as liners [7,11,25,29]. Estafan, et al.[11] have confirmed the efficiency of this technique to improve the marginal adaptation of composite restorations. The first generation of flowable composites was introduced in the late 1996[4]. These composites were created by retaining the same small particle sizes of traditional hybrid composites, but reducing the filler content and allowing the increased resin to reduce the viscosity of the mixture[4]. Because flowable composites are richer in resin than traditional composites, their elastic modulus is lower, so their tenacity values are better than those of conventional materials[4]. In addition, Yazici, et al.[29] showed that the combination of flowable composite resins and hybrid composites yields the most effective reduction in microleakage.

Therefore, based on the literature related to the adhesive restorative technique and its restrictions, this study intended to evaluate the influence of the use of resin liners on the microleakage of class V composite resin restorations prepared in dentin margins of bovine teeth.

MATERIAL AND METHODS

The following materials were selected for this study,: Scotchbond multi purpose bonding system (3M ESPE, St. Paul, MN, USA), the filled adhesive Optibond FL (Kerr Corp, Orange, CA, USA), the low viscosity composite resin Flow-it (Jeneric/Pentron, Wallingford, CT, USA), and the hybrid restorative composite Z100 (3M ESPE, St. Paul, MN, USA). The description and composition of these materials are described in Table 1.

Forty freshly extracted bovine incisors were selected because bovine teeth are suitable substitutes for human teeth for in vitro microleakage studies[23]. These teeth were cleaned and scaled with a periodontal curette to remove tissular remnants. Prophylaxis was provided using pumice and water paste on a Robinson brush at low-speed handpiece (Kavo, Joinville, SC, Brazil).

After the cleaning procedures, these teeth were examined

TABLE 1- Description of the restorative materials and bonding systems used in this study

Material	Type	Composition
Z 100	Hybrid composite resin	Bis-GMA, TEGDMA - Zirconium / silica filler
Flow-It	Flowable composite resin	Barium fluorosilicate filler, silica, Bis-GMA, TEGDMA, titanium dioxide.
Scotchbond Multi Purpose	Bonding system	Etching- 35%phophoric acid Primer- HEMA, polyalcenoic acid, water Adhesive- Bis-GMA, HEMA
Optibond FL	Filled adhesive	Adhesive- Bis-GMA, HEMA, silica, barium glass

under stereomicroscopic lens (Zeis, Manaus, AM, Brazil) at 20x magnification in order to detect possible cracks or structural alterations of enamel that could interfere with the study results. Then, the teeth selected were stored in distilled water under refrigeration (4°C), for no more than a week.

Standard class V cavity preparations were prepared on the buccal surface, just below the cementoenamel junction, with enamel and dentin margins. The cavities were prepared with a wheel bur - FG 3053 (KG Sorensen Industria e Comercio Ltda, Sao Paulo, SP, Brazil) measuring 4mm in diameter and 1.5mm in height at high-speed under cooling. The cavity had circular shape with 2mm in depth and approximately 4mm in diameter. The C-factor of the cavity was 3[12], simulating a clinical situation of extreme stress.

The teeth were randomly assigned to four groups of 10 teeth each, according to the restorative technique used:

· Group 1 – Application of Scotchbond Multi Purpose adhesive system according to the manufacturer's instructions (35% phosphoric acid gel was applied to the enamel and dentin for 15 seconds and rinsed for 10 seconds). Excess water was removed using an air syringe, leaving the surface slightly moist. The SBMP primer solution was applied on the tooth substrate and gently dried for 5 seconds in order to render a shiny surface. Then the SBMP adhesive was applied on the enamel and dentin and light-cured for 10 seconds. Z100 composite resin was inserted in a single increment and light-cured for 40s (Control).

· Group 2 – Application of Scotchbond Multi Purpose adhesive system according to the manufacturer's instructions, but the adhesive was applied in 3 layers that were individually light-cured for 10 sec. Z100 composite resin was inserted in a single increment and light-cured for 40s.

· Group 3 – Application of Scotchbond Multi Purpose adhesive system according to the manufacturer's instructions, followed by application of one layer of the filled adhesive Optibond FL. Z100 composite resin was inserted in a single increment and light-cured for 40s.

· Group 4 – Application of Scotchbond Multi Purpose adhesive system according to the manufacturer's instructions, followed by application of low viscosity composite Flow-It as a liner. Z100 composite resin was inserted in a single increment and light-cured for 40s.

All composite resins were light-cured using an XL 2500 light source (3M ESPE, St. Paul, MN, USA) with a light intensity of 600mW/cm^2, assessed with a radiometer (Demetron, Kerr, Orange, CA, USA) every 5 restorations.

After the restorative procedure was completed, the specimens were stored in distilled water at 37ºC for 24 hours. Afterwards they were finished using fine diamond burs (Fava, São Paulo, SP, Brazil) and polished using paper disk Sof-lex (3M ESPE, St. Paul, MN, USA). Then the samples were stored in distilled water at 37ºC for 24 hours.

For the microleakage test, the apices were filled with composite resin to prevent infiltration of the dye solution through this area. The specimens were then entirely covered with two layers of nail varnish, except for the class V filling and one millimeter beyond the margins. The teeth were immersed in buffered 2% methylene blue dye solution. After 2 hours in this solution, the teeth were rinsed in tap water for 10 minutes and all the coating was removed.

After the cleaning procedure, the specimens were half sectioned through the center of each restoration using a slow-speed diamond saw (South Bay Technology, San Clemente, CA, USA), at low-speed under liquid cooling. The sections were evaluated by three independent calibrated examiners on a stereomicroscope at 40x magnification to verify the dye penetration, and the following criteria were used to score the extent of leakage at the dentin margins:

0 – no dye penetration;

1 – dye penetration into the cervical wall without reaching the axial wall;

2 – dye penetration including the axial wall.

The examiners re-evaluated the specimens if there were any discrepancies, and consensus was reached if disagreements occurred.

The method used, as well as the quantification of microleakage, was based on ISO TR 11405, 2003[13].

The Kruskal-Wallis test statistically examined the microleakage data in the four groups. Computation of significant differences was assigned at a=0.05.

RESULTS

The frequency of microleakage at the gingival margins is shown in Table 2 and the multiple comparisons from the data obtained are listed in Table 3. Statistical analysis using the Kruskall-Wallis test (5%) showed that Group 4 (Flow-it

TABLE 2- Frequency of microleakage scores

Leakage score	Group 1	Group 2	Group 3	Group 4
0	0	0	1	2
1	3	3	1	4
2	7	6	8	4

TABLE 3- Multiple comparisons from the data obtained by the Kruskall-Wallis test at 5% significance

Groups	5%	P
1, 2	NS	0.6011
1, 3	NS	0.9348
1, 4	S	0.0317
2, 3	NS	0.5155
2, 4	NS	0.0707
3, 4	NS	0.0591

Contrasts marked with " S " show statistical difference.

liner) presented significantly less leakage than Group 1 (1 adhesive layer) ($p<0.05$). Groups 2 (3 adhesive layers) and 3 (Optibond FL liner) showed intermediate values and there were no statistical differences when they were compared to the values of the other groups ($p>0.05$).

DISCUSSION

Microleakage is defined as the clinically undetectable passage of bacteria, fluids, molecules or ions between the cavity wall and the restorative material applied to it[15]. Evaluation of microleakage is the most common method to assess the sealing efficiency of a restorative material[2].

Several microleakage studies have demonstrated that it is more difficult to seal the cervical dentin margins[7,24], so this study was accomplished considering just the dentin substrate to evaluate the microleakage levels. Dentin was defined by Marshall[18] as a vital complex hydrated composite. There is a large heterogeneity on the dentin composition, with great variation in the configuration of the dentinal tubuli at the cervical wall[18, 22]. All these characteristics may play an important role in dentin bonding, leading the adhesive bonding to be a challenge to clinicians. In addition to this, the acid etching technique in enamel provides optimal anchorage, capable of resisting to the contraction forces resulting from the composite resin polymerization. It means that, during the polymerization process, the composite resin shrinks towards the enamel margins, thus forming a gap at the interface between cementum/dentin and the composite [7], confirming the importance of evaluating the dentin wall.

Among the factors that cause immediate marginal failure and subsequent microleakage, the stress generated during polymerization can be considered the most important[6,10,12,27]. Carvalho, et al.[6] reported that the polymerization shrinkage of a composite resin can generate contraction forces that may disrupt the bonding to cavity walls.

The marginal integrity and the polymerization stress are inversely correlated with the Young's modulus of the restorative composite[14]. However, it is also important that the restorative materials have a rigid characteristic, according to Abdalla, Davidson[1], who verified that the elastic modulus of the restorative composite should be higher than that of dentin, so that the restoration can resist to occlusal loading. The restorative composite used in this study was Z100, which has an elastic modulus of 20.1Gpa[27]. This modulus is higher than the dentin modulus (10.3GPa, according to Meredith, et al. [19]), but it is high enough to produce strong polymerization stress at the dentin/composite interface. It has been reported that any material with a high elastic modulus will frequently destroy the bond, leading to poor marginal quality[6,10,14,27,29]. Consequently, any material that reduces the polymerization shrinkage stress at the interface would have a desirable ability to withstand 'plastic flow' during its initial polymerization phase – allowing the material to absorb and support the strain and reducing the effect of a rigid contraction at the interfaces[14]. If the walls of a cavity are provided with an elastic layer, the bulk shrinkage of the restoration can obtain some freedom of movement from the adhesive side. Moreover, the lining might contribute to a more uniform distribution of the stress over the adhesive interface[10]. Kemp-Scholte, Davidson[14] found a strong correlation between marginal adaptation and flexibility of the restorative system.

The restorative technique with resin elastic liners and rigid restorative composites might be a suitable alternative to reduce stress at the dentin/composite interface and to avoid deformation by occlusal loading. Unfortunately, the results of the present study show that none of these restorative techniques totally prevented microleakage at the composite/dentin interface. However, there was a reduction in the microleakage levels using the flowable composite as a liner.

Flowable composites are characterized by fluid injectability into cavities[4]. These composites show reduction on the filler content and addition of rheological modifiers. This condition causes reduction of viscosity and elastic modulus, making these materials more flexible[27]. Flow-it is a first-generation low-viscosity composite, with borosilicate glass as its filler (70.5% by weight), with an average diameter of 1.5mm. In this study, the use of resin liner with Flow-it actually reduced the microleakage levels. These findings are in agreement with the findings of other studies[11,25,29]. The improved performance of the resin liner restoration was attributed to the stress absorption by this elastic layer. Yet, the reduction of the volume of restorative composite applied to the cavity cannot be neglected – it causes a reduction in polymerization shrinkage, provoking some decrease in contraction stress and allowing better marginal adaptation [6,10]. Montes, et al.[20] have verified that low-viscosity intermediate resin will act as a stress absorbing layer due to its lower elastic modulus, which allows deflection between the rigid traditional composites and the dentin substrate, improving the marginal seal and increasing the longevity of the dentin bond. They suggested that the use of an intermediate low elastic modulus layer would function as a shock absorber or a 'stress-breaker'.

In 2000, Choi, et al.[8] demonstrated that the polymerization shrinkage stress generated during placement of the composite restoration was found to be significantly absorbed and relieved by the application of an increased thickness of low stiffness adhesive, reducing microleakage. However, this could not be observed in this study, because Group 2 (three adhesive layers) was not statistically different from the control group. Considering that the stress absorption is directly related to the liner thickness and elastic modulus, it can be inferred that the adhesive layer was not thick enough to produce effective reduction of stress, because the elastic modulus of SBMP is 4.5Gpa[27]. When placed in a sufficiently thick layer, the adhesive resin – due to its relatively high elasticity – may act as a stress-relaxation buffer. This would partially absorb the tensile stress imposed by polymerization shrinkage of the restorative composite by the elastic elongation. Besides, the large volume of restorative composite may generate great stress at the interface, and in this case the adhesive layer could not relieve this stress. In addition, it should be noted that the application of thicker layers of adhesive has some drawbacks. A thick layer of unfilled adhesive at the margin of a restoration may lead to more wear at this region. Moreover, the adhesive is radiolucent, what may pose diagnostic problems at subsequent examinations[8].

To overcome such problems, filled adhesives have been proposed to increase the adhesive thickness combined with radiopacity. They can improve the marginal quality and solve the diagnostic problem. For Optibond FL, the barium glass filler gives the bond a gel consistency, which, based on the theory of 'elastic cavity wall', improves the adhesive strength, reduces the polymerization shrinkage of the adhesive resin and increases the adhesive thickness. Tam, et al. [26] demonstrated that filled adhesives can improve the properties of the dentin/composite interface by increasing the interfacial fracture resistance and the dentinal seal. Braga, et al. [5] observed that filled adhesives permit a more homogeneous distribution of the stress generated at the bonded interface. Therefore, it was expected that this thicker resin layer would improve the marginal quality and decrease the microleakage levels. Nonetheless, Nunes, et al.[21] stated that the bond strength was not improved by the application of filled adhesives. Furthermore, in this study the use of filled adhesive did not improve the marginal seal either, because there were no statistical differences when Group 3 was compared to the control group. This was also probably caused by the large resin volume applied on the cavity. The stress transmitted to the interface in this situation was greater than the bonding strength, and marginal gaps were formed to allow microleakage. Perhaps if there was a reduction on the volume of restorative composite by the incremental technique, for example, the effect of the filled adhesive and thicker unfilled adhesive layer could be noted.

The results showed that the marginal leakage was not prevented by any of the restorative techniques. The quality of sealing at the resin/dentin interface remains unsatisfactory. Therefore, it can be concluded that there is no straightforward manner to handle the adhesive restorative materials in order to guarantee a leak-proof restoration. A proper understanding of the mechanisms that cause the problems, together with techniques that may reduce their effects, as the resin liners, will help the practitioner to get the maximum benefit out of the application of composite resins in restorative dentistry.

CONCLUSION

Whitin the limitations of this in vitro study, the following conclusions can be drawn:

1. None of the restorative techniques completely sealed the tooth/restoration interface at cervical margins
2. The use of a resin liner using a flowable composite may be advantageous in reducing the microleakage level at cervical margins.
3. The use of a filled adhesive could not reduce the microleakage level when compared to the conventional technique.
4. The use of a thicker adhesive layer could not reduce the microleakage level when compared to the conventional technique.

RESUMO

Objetivo: O objetivo desse estudo foi avaliar os efeitos da aplicação de um adesivo em diferentes espessuras ou em associação com um adesivo com carga ou com compósito de baixa viscosidade na microinfiltração marginal de restaurações com compósito odontológico. Métodos: Quarenta incisivos bovinos foram selecionados e cavidades circulares (4mm de diâmetro X 2mm de profundidade) foram preparadas na região da junção cemento-esmalte. Os dentes foram então divididos em quatro grupos de acordo com o forramento utilizado: 1: (controle) aplicação do sistema de união Scotchbond Multi Uso (SBMU) – 1 camada de adesivo; 2: aplicação de 3 camadas do adesivo SBMU; 3: aplicação do SBMU, seguido pela aplicação de uma camada do adesivo Optibond FL; 4: aplicação do SBMU seguido pela aplicação de forramento com o compósito de baixa viscosidade Flow-it. Todas as cavidades foram restauradas com o compósito Z100. O teste de microinfiltração foi conduzido de acordo com a ISO (TR11405). Os dados foram analisados pelo teste de Kruskall-Wallis (p>0,05). Resultados: O grupo 4 apresentou redução significativa dos níveis de infiltração quando comparado ao grupo 1. Os grupos 2 e 3 apresentaram valores intermediários e não foram detectadas diferenças significativas quando estes grupos foram comparados aos grupos 1 e 4. Conclusão: O uso de forramento com compósito de baixa viscosidade pode reduzir os níveis de infiltração marginal, possibilitando melhora na qualidade das restaurações em compósito odontológico.

UNITERMOS: Compósito de baixa viscosidade; Adesivo com carga; Restaurações em compósito; Microinfiltração.

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