

Marginal microleakage in Bulk Fill resins

Microinfiltração marginal em resinas Bulk Fill

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Resumo

Introdução: Apesar dos avanços e inovações na odontologia restauradora, a microinfiltração continua sendo um dos principais problemas nessa área. **Objetivo:** Avaliar “in vitro” a microinfiltração marginal das resinas Bulk Fill em cavidade classe II, com terminação cervical em dentina. **Material e método:** Cavidades padronizadas na mesial e distal foram elaboradas em quarenta dentes molares superiores e alocados aleatoriamente em quatro grupos (n=10), de acordo com a resina usada: G1 (controle): Filtek Z350(3M/ESPE); G2: Filtek Bulk Fill flow (3M/ESPE); G3: Surefill SDR (Dentsply); G4: X-tra base (Voco), sendo estes subdivididos em subgrupos considerando a estratégia adesiva aplicada (autocondicionamento e convencional). Após 24h de armazenamento em estufa (37 °C), as amostras foram submetidas ao teste de termociclagem (500 ciclos: 5 °C/55 °C). Posteriormente foram impermeabilizadas, imersos em Fucsina Básica (0,5%) e seccionados no sentido méso-distal para avaliação com lupa estereoscópica 40X (Coleman), sendo atribuído escores de 0 a 3 de acordo com a microinfiltração observada. Para análise estatística foi aplicado o teste Mann-Whitney e o Kruskal-Wallis com nível de significância de 5%. **Resultado:** Não houve diferença estatística significativa entre as resinas Bulk Fill, quando utilizada a técnica de condicionamento ácido total. Apenas a resina Filtek Bulk fill flow apresentou resultados estatisticamente significante quando se considerou a estratégia de aplicação do sistema adesivo, com piores resultados, em relação aos outros grupos. **Conclusão:** O grau de infiltração em cavidades classe II das resinas bulk fill estudadas, não foi influenciado pelo modo de aplicação do sistema adesivo (convencional ou autocondicionante), exceto para Filtek Bulk fill flow.

Descritores: Resinas compostas; adesivo; infiltração.

Abstract

Introduction: Despite advances and innovations in restorative dentistry, microleakage remains one of the main problems in this area. **Objective:** To evaluate *in vitro* marginal microleakage of Bulk Fill resins in class II cavities, with cervical termination in the dentin. **Material and method:** Cavities, standardized on the mesial and distal surfaces, were prepared in forty top molars and randomly assigned to four groups (n = 10), according to the resin used. G1 (control): Filtek Z350 (3M/ESPE); G2: Filtek Bulk Fill flow (3M/ESPE); G3: Surefill SDR (Dentsply); G4: X-tra (Voco). These were further subdivided into subgroups according to the strategy used to apply the adhesive (self-etch technique and conventional). After storage for 24 hours in an oven (37 °C), the samples were submitted to the thermocycling test (500 cycles: 5 °C/55 °C). They were later waterproofed, immersed in Basic Fuchsin (0.5%) and sectioned in the mesial-distal direction for evaluation using a stereo magnifying glass at 40X (Coleman) Scores from 0 to 3 were assigned according to the microinfiltration observed. The Mann-Whitney and Kruskal-Wallis tests, with a significance level of 5%, were used for statistical analysis. **Result:** There was no statistically significant difference between the Bulk Fill resins when the total acid-etching technique was used. Only the Filtek Bulk fill flow resin presented statistically significant results when the application of the adhesive system strategy was considered, with worse results, in relation to other groups, when it the self-etching strategy was considered. **Conclusion:** The degree of leakage of the bulk fill resins studied, in class II cavities, was not influenced by the method of application of the adhesive system (conventional or two-step self-etching bonding agent), except for the Filtek Bulk fill flow.

Descriptors: Composite resins; adhesive; leakage.

INTRODUCTION

The penetration of fluids and bacteria into the restorative interface continues to be one of the main problems of dentistry, and is associated directly with the longevity of the restorations.

Marginal microleakage carries problems like discoloration and marginal degradation, early loss of the restoration due to recurring caries, post-operative sensitivity and/or pulpal damage¹⁻³.

Alternatives are being studied to try to minimize or eliminate the indices of microleakage in restorations of composite resins. In this context, there are bulk fill compound resins whose insertion technique involves a single increment, up to 6mm thick, in subsequent direct restorations^{4,5}.

The conventional flow of composite resins is of low viscosity with a reduced percentage of filler particles (44-55% in volume) and a greater amount of resinous components, leading to a considerable shrinkage during the polymerization process. Although the resins have flow bulk fill composition viscosity and the like, have polimerização^{6,7}. These modulators interact with camphorquinone, thus reducing the contraction module and increasing the number of linear constraints, generating less contraction stress and degree of polymerization preserved, the extension of the pre-gel stage⁸.

However, the scientific literature has not yet established whether these filler materials, *en masse*, provide good marginal adaptation. Therefore, this study had the objective of evaluating the degree of marginal microleakage of bulk fill restorative materials *in vitro*,

considering different application strategies for the universal adhesive system, both conventional and self-etching.

The null hypotheses tested were that there would be no difference in marginal microleakage between the bulk flow and universal (control) resins, and that the method of applying the adhesive system would not influence marginal microleakage.

MATERIAL AND METHOD

Preparation of the Samples

Forty molars, recently-extracted for therapeutic purposes and free from caries and structural defects, were selected for the present study. Immediately after extraction, the teeth were, scrapings prophylaxis was performed using an aqueous pumice paste and disinfection in a thymol solution (0.1%) for 24 h.

The teeth were divided randomly into four groups (Table 1): Group I – control; Groups II, III, IV and the class II preparations (vertical slot) were performed on the mesial and distal surfaces

Table 1. Materials, composition and application protocol

Materials /LOT	Composition	Method of application			
Scotchbond universal (3M ESPE, St Paul, MN, EUA) (N522489)	Part Primer: Methacrylates phosphate, Vitrebond copolymer, Bis-GMA, HEMA, water, ethanol, silica particles treated with silane, initiators and stabilizers Adhesive part: hydrophobic dimethacrylate, methacrylate phosphate, TEGDMA Silica particles treated with silane, Initiators and Stabilizers	Total etching	etching for 15 sec. Rinse for 15 seconds. Remove excess water.	Dentine wet	Apply the adhesive for 20s with vigorous stirring. Photopolymerize for 10s (1200mW/cm ²).
		Selective conditioning	Idem	Dentine wet	Idem
Z350 3M/ESPE (N5619664)	Organic Matrix: Bis-GMA, UDMA and Bis-EMA. inorganic filler: silica-zirconia particles 82% by weight and 60% by volume (load) incremental insertion of 2 mm photoactivation for 40 seconds each increment	Insertion in single 4mm increment, photoactivation for 20s			
Filtek Bulk Fill flow 3M/ESPE (N473386)	Bis-GMA, Bis-EMA, UDMA and polyacrylic resin; Ytterbium trifluoride (0.1-5.0µm), zirconia/silica (0.01-3.5µm); 64% by weight and 42.5% by volume.	Insertion in single 4mm increments, photoactivation for 20s			
Surefil11ill SDR flow Dentsply (130103)	Glass of barium boron fluoride aluminum silicate, glass of strontium aluminum fluoride silicate; Modified urethane dimethacrylate resin; ethoxylated bisphenol A dimethacrylate (EBPADMA); triethyleneglycol dimethacrylate (TEGDMA); camphorquinone (CQ) as photoinitiator; butyl hydroxy toluene; UV stabilizers; titanium dioxide; iron oxide pigments.	Insertion in single 4mm increments, photoactivation for 20s			
X-tra base flow Voco (1341137)	Bis-GMA, UDMA, TEGDMA Filler particles not informed by the manufacturer (75% inorganic filler) I	Insertion in single 4mm increments, photoactivation for 20s			

Bis-GMA, bisphenol-A-glycidyl-dimethacrylate; DDDMA, dodecanediol dimethacrylate; EBPADMA, ethoxylated bisphenol-A-dimethacrylate; TEGDMA, triethylene glycol dimethacrylate; UDMA, urethane dimethacrylate. Source: Data were extracted from the package inserts of each material, following the technical specifications provided by each manufacturer.

with the gingival end in dentin. All preparations were performed using n° 1092 diamond burs (KG Sorensen – São Paulo, Brazil), changed every five preparations, adapted in a high-speed turbine and connected to a calliper, standardizing the dimensions of the cavity box at 8 x 4 x 4 mm, and set 1.0 mm beyond the dentinoenamel junction.

Restorative Procedure

The strategy for applying the Scotchbond universal system (3M-ESPE) constituted a subdivision of the groups (Table 1), with the self-etching mode using selective conditioning, and total acid conditioning (37% phosphoric acid). Subsequently, the solvent was evaporated using a gentle air stream for 5 seconds, the adhesive was photopolymerized for 10 seconds using an LED photopolymerizer (Optilight – Gnatus, Ribeirão Preto, São Paulo, Brazil) at a 1 mm distance, according to manufacturer's instructions. The intensity (1200mW/cm²) of the device was checked periodically. Following application of the adhesive system, all cavities were filled with the bulk fill resins of each group in single increments of 4mm: G2, Filtek Bulk Fill (3M/ESPE); G3, Surefill-SDR (Dentsply); G4, X-tra base (Voco), and the incremental technique of 2 mm, the control group (G1) using Filtek Z350 (3M/ESPE), also photoactivated using the LED device (Optilight – Gnatus, Ribeirão Preto, São Paulo, Brazil) for 20 or 40 seconds, according to manufacturer's instructions. Finally, the finishing and polishing of the restorations, using Sof-Lex (3M/ESPE) aluminum oxide sanding disks in fine and ultra-fine granulations, was performed. The apices were then sealed with acrylic resin and the teeth were stored for 24 hours in distilled water at 37°C. All procedures were performed by the same operator.

Microleakage Analysis

The samples from each group were submitted to 5000 cycles of thermocycling (5°C and 55°C) for minute, waterproofed with two layers of cyanoacrylate (Superbond, Loctite, Brazil) and two layers of nail polish (Colorama, Brazil), at a distance of about 1 mm from the edges of the fillings. They were subsequently immersed in basic fuchsin (0.5%) for 24 hours at room temperature. After removal of the dye, the teeth were washed in running water for 5 minutes and sectioned longitudinally in the mesial-distal direction in the center of the restoration using a double-faced diamond disk (KG Sorensen – São Paulo, Brazil). The evaluation of microleakage at the tooth/restoration interface appeared in a qualitative way using a stereo microscope at 40X (Coleman, Santo André SP, Brazil) by three previously calibrated examiners. The evaluation used the

following scores: 0 – no penetration of the dye; 1 – penetration of the dye along the nail polish; 2 – penetration of the dye along the dentinoenamel junction (DEJ), but not including the pulpal wall; 3 – penetration of the dye along the pulpal wall. The classification of Altman et al. (1991) was used to measure the between-examiner Kappa index, and the level of agreement in the present study was 0.83.

The Mann-Whitney and Kruskal-Wallis tests, from the Statistical Package for the Social Sciences (SPSS), version 21, were used to analyze the data. The 5% margin of error was used.

RESULT

None of the restorative materials studied, as well as the different adhesive strategies, were able to eliminate marginal microleakage completely. There was no statistically significant difference between the Bulk Fill flow resins when the application strategy of the adhesive system was considered, except for the Filtek Bulk Fill flow (Table 2).

DISCUSSION

The present study evaluated the marginal sealing capacity of bulk fill composite resins in Class II cavities, ending in the dentin. The results led to a partial rejection of the first null hypothesis which assumed no statistically significant difference in marginal microleakage between the bulk fill flow resins and the control, universal resin. The control group (G1) showed microleakage indices similar to those of groups G2 and G4, all formed by resins marketed as having low contraction. The similarity of the results between the methacrylate-based resins may be explained by the similarity of the compositions and by the use of adhesive systems that involve acid etching of the dentin. Translucency has also been indicated as a relevant property for uniform polymerization in all the material⁹.

The Surefill SDR provided the best results among the bulk fills, agreeing with Scotti et al.¹⁰ and Roggendorf et al.⁵, but disagreeing with the study by Juloski et al.⁴ The bulk fill flow resins are considered to have low modulus of elasticity¹¹, with lower wettability than the conventional ones and, for having low viscosity, may be inserted easily into small cavities and are expected to adapt better.¹² However, this contradicts the results of the present study when comparing the results of the bulk fill with the control resin (Z350). Previous studies also do not agree with our results when they show statistically significant results with low-viscosity composites in reducing microleakage in the dentin¹⁰. Here, it is noteworthy that the dentin

Table 2. Means of the posts and between-groups comparative result

Tipo		Groups				p value
		Z350XT	Filtek/BF	Surefill SDR	Xtra base	
• Self-etching	Means	14.50 ^(A)	31.50 ^(B)	14.50 ^(A)	30.70 ^(B)	p ⁽¹⁾ = 0.007*
• Total acid conditioning	Means	14.50 ^(A)	18.20 ^(A)	18.20 ^(A)	21.90 ^(AB)	

* Significant difference at the 5.0% level; ⁽¹⁾ Through the Kruskal test, with comparisons of that test. Obs.: If the letters in parentheses are different, it shows significant differences between the groups.

is a complex structure, rich in organic molecules, which makes adhesion in this substrate more difficult to achieve¹¹.

Of the resins used in the present study, it is the Xtra base[®] that has the highest filler content (75% by volume) and the smallest particles, and that showed the largest index of marginal microleakage. Based on the principle that the greater formation of stress in Class II restorations would lead to a greater formation of marginal gaps and, considering that the degree of contraction is closely related to the filler content and the tensions generated at the tooth/restoration interface, the results obtained here are questionable. One possible explanation for the lower results is the possibility of restriction of mobility having occurred in the reactive species and the diffuse scattering of the activating light.¹³ All resins were used according to the manufacturers' recommendations, using the universal Single Bond adhesive system. Thus, for the purpose of analyzing the presented results, the restorative system should be considered as a whole; that is, the set "adhesive system + composite resin".

The second null hypothesis, which stated that the method of adhesive application would not influence marginal microleakage, was accepted with reservation because only the Filtek Bulk Fill[®] flow was influenced by the method of application of the universal single bond adhesive. The results obtained may be related directly to the adhesive system used since studies report that, despite the capacity of the chemical to adhere to the tooth, it has presented slightly lower results than the Clearfil SE Bond adhesive. This is possibly due to the interaction between different chemical components present in the material^{14,15}. The composition of the single bond shows, in addition to the monomer 10-MDP, the Vitrebond copolymer which is also capable of establishing chemical bonds with the free Ca⁺ ions. The presence of the copolymer may have negatively influenced the adhesion process, if the hypothesis of having had a co-dispute for the establishment of carbon double bonds between this and the 10-MDP is considered¹⁵.

Considering the limitations of the present study, it can be concluded that none of the restorative materials was capable of eliminating marginal leakage, regardless of the adhesive strategy used.

Other, added factors, like the form of the application, the type of solvent and the pH may help to explain the results presented here, especially the vigorous application. It has already been demonstrated that the vigorous application of self-etching adhesives improves the resistance of immediate union, and reduces the degradation of the union over time^{16,17}. Appropriate control of dentinal humidity for subsequent diffusion of resinous monomers is fundamental, especially for the pressure of the solvent vapor which is directly related to adhesive quality¹⁸.

As for the evaluation method used, it is known that this is influenced by the capacity of the dye to penetrate and by the intra- and inter-examiner reliability, which must not be low. This method has been challenged for being a form of evaluation of a subjective, in which the degree of penetration of the dye is calculated through the scores¹⁹. Thus, to minimize the inter-examiner subjectivity, the evaluators in the present study underwent a calibration process and the Kappa index was calculated (K > 82%). Other techniques have been used to measure the level of microleakage; among them, compressed air, electrochemical investigations, scanning electron microscopy and, more recently, micro-CT images^{20,21}. Despite advances in the technology which allow the use of micro-CT in the evaluation of microleakage, some authors report that the best images were obtained using stereo-microscopy²². According to De Santi et al.²³ since there was good inter- and intra-examiner agreement, any one of the techniques may be used. The authors also report that micro-CT is still not ready to replace the method of scores as the gold standard in the evaluation of microleakage.

CONCLUSION

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CONFLICTS OF INTERESTS

The authors declare no conflicts of interest.

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