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Flowable Composites as "Filled Adhesives:" A Microleakage Study

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Abstract

Objective: The purpose of this *in vitro* study was to investigate the microleakage at dentin margins of a flowable resin composite associated with an adhesive, either light cured separately or co-cured, in Class V cavities.

Materials and Methods: Twenty four recently extracted human molars were prepared with standardized box-shaped Class V cavities of 3.0 mm (mesial-distal), 2.0 mm (occlusal-gingival), and 2.0 mm depth with margins located on enamel and dentin/cementum on the buccal or lingual surfaces. The cavities were randomly assigned into three groups (n=8): Group I – Single Bond + Filtek Z250 (control); Group II – Single Bond + Filtek Flow (light cured separately) + Filtek Z250; and Group III – Single Bond + Filtek Flow co-cured (light cured simultaneously) + Filtek Z250. After being immersed in tap water for 24 h, the specimens were thermocycled (1000x, 5°-55°C, 30 sec dwell time) and immersed in a 0.5% basic fuchsine solution for 24 h. The restorations were sectioned longitudinally and gingival margins were evaluated for microleakage using a 0-4 scale. Data were subjected to the Kruskal-Wallis test at $p<0.05$.

Results: A statistically significant difference at $p = 0.0044$ between Groups 1 and 3 and Groups 2 and 3 was observed. Although Group 2 performed slightly better than Group 1, no significant difference was observed.

Conclusion: The use of a flowable resin composite cured simultaneously with an adhesive yielded the worst results in this study. As no statistical differences were seen between Groups 1 and 2, the use of a flowable composite as a means of minimizing microleakage at dentin margins may be questioned.

Keywords: Flowable, microleakage, composite resin, co-cured, light curing

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Introduction

Today, aesthetic restorative dentistry is based on adhesive procedures that approach increased retention, resistance of the tooth-restoration interface, and, hence, better marginal sealing. Since the clinical success of adhesive procedures relies on approaches for polymerization shrinkage control and establishment of a predictable adhesion, a number of different materials and clinical procedures have been advocated with this objective and, among several protocols, the use of flowable composites has been suggested as a means to reduce the possibility of microl eakage.[1,2,3,4,5,6,7] Co-curing the adhesive and a flowable composite has also been occasionally recommended, although supporting evidence is sparse.[8,9]

The objective of this *in vitro* study was to investigate the microleakage at dentin margins of a flowable resin composite associated with an adhesive, either light cured separately or co-cured, in Class V cavities.

Material and Methods

Specimen Preparations

Twenty-four caries-free freshly extracted human third molars were selected and stored for less than 3 months in physiologic solution. In each tooth, a standardized box-shaped Class V cavity of 3.0 mm (mesial-distal), 2.0 mm (occlusal-gingival), and 2.0 mm depth was prepared on the buccal or lingual surfaces with the occlusal margin located 1.0 mm on enamel and the gingival margin located 1.0 mm on dentin/cementum by means of inverted cone carbide burs (# 330, KG Sorensen, SP, Brazil) in a water-cooled high-speed handpiece. Each bur was used for four preparations and then replaced.

Restorative Procedures

The teeth were randomly assigned into three groups of eight restorations each (four teeth per group, n=8). The restorations were placed by a single, previous calibrated, operator. In all groups the total etch technique was performed prior to the establishment of the adhesive layer. A 35% phosphoric acid (Scothbond Etchant Gel, 3M-ESPE, St. Paul, MN, USA) was applied initially to the enamel margins and then extended from the superficial to deep dentin for 15 sec. After application of the acid gel, the substrate was washed with an air/water spray for 30 sec and excess humidity was removed by a cotton pellet applied on the dentin while the enamel was gently air dried. In Group 1 an adhesive system (Single Bond, 3M-ESPE, St. Paul, MN, USA) was applied according to the manufacturer's instructions and light cured for 20 sec, then a composite (Filtek Z250, 3M-ESPE, St. Paul, MN, USA) was applied in a bulk increment and light cured for 20 sec to restore the cavities. In Group 2 Single Bond (3M-ESPE) was applied according to the manufacturer's instructions and light cured for 20 sec. A flowable composite (Filtek Flow, 3M-ESPE, St. Paul, MN, USA) was placed in a 0.5 mm thick layer and light cured for 20 sec. Then Filtek Z250 (3M-ESPE) was applied in a bulk increment and light cured for 20 sec to restore the cavities. In Group 3 Single Bond was applied in only one layer that was gently air dried and covered with a 0.5 mm thick layer of Filtek Flow (3M-ESPE). This two-component layer was co-cured (light cured simultaneously) for 40 sec. Then Filtek Z250 (3M-ESPE) was applied in a bulk increment and light cured for 20 sec to restore the cavities. For polymerization, a standard light curing unit (XL 2500 3M-ESPE, St. Paul, MN, USA) at 500 mW/cm2 was used from a distance of 0.5 mm from its outer surface. After immediate finishing and polishing with sequential disks (Sof Lex Pop-On, 3M-ESPE, St. Paul, MN, USA) the teeth were stored in distilled water as described in the, "Assessment Procedure", section to follow. The materials used and the experimental groups are described in Tables 1 and Figure 1.

Assessment Procedure

The restored teeth were stored for 24 h in distilled water. The specimens were then thermocycled for 1000 cycles, with baths held between 5˚C and 55˚C, a dwell time of 30 sec, and a transfer time of 3 sec. The root apices were sealed with epoxy resin (Araldite, Ciba-Geigy, Basel, SW), and all external surfaces of each specimen were isolated with 1 layer of sticky wax and 2 layers of nail polish except for an area within 1.0 mm around the restoration. The teeth were then immersed in a 0.5% basic fuchsine solution for 24 h at room temperature. After immersion, the teeth were cleaned and the restorations were sectioned in the middle of the restorations with a low-speed diamond saw (Isomet, Buehler Ltd, Lake Buff, IL, USA) resulting in 2 sections for each

Table 1. Materials used in this study.

Materials	Composition	Batch Number	Manufacturer
3M Scothbond Etchant	35% phosphoric acid, colloidal silica	2BL	3M ESPE
Single Bond	HEMA, Bis-GMA, PAA, ethanol, and water	2KW	3M ESPE
Filtek Flow	Zirconia/silica filler, UDMA, Bis-GMA, TEG-DMA, and water	OEG	3M ESPE
Z 250	Zirconia/silica filler, BPGMA, UDMA, Bis-GMA, TEG-DMA, and water	OTC	3M ESPE

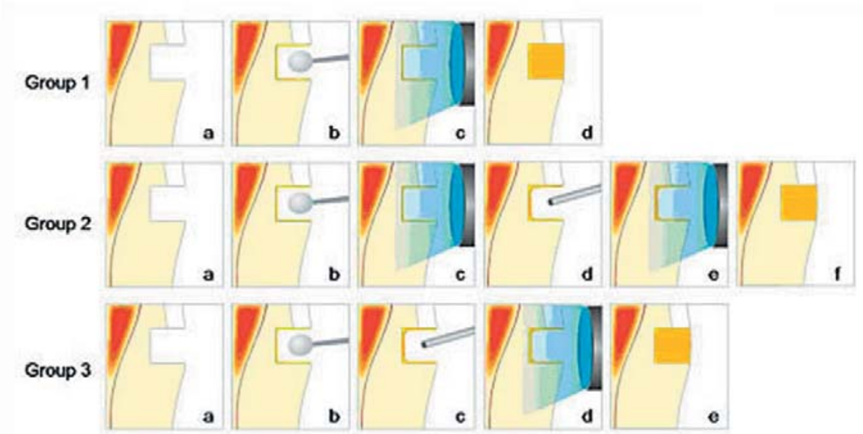

Figure 1. Experimental groups. Group 1 (control): a) Class V cavity; b) adhesive application; c) light curing (20sec); d) composite placement. Group 2 (flowable): a) Class V cavity; b) adhesive application; c) light curing (20 sec); d) flowable composite placement; e) light curing (20 sec); f) composite placement. Group 3 (co-cured): a) Class V cavity; b) adhesive application; c) flowable composite placement; d) co-curing (adhesive + flowable composite) (40 sec); e) composite placement.

restoration. The one which was most infiltrated was considered and recorded for microleakage. The sections were observed under an optical microscope at 40x magnification, and the extent of dye penetration was assessed according to a 0 to 4 scale:

- 0 = no dye penetration
- 1 = dye penetration up to 1/3 along the gingival wall
- 2 = dye penetration up to 2/3 along the gingival wall without reaching the axial wall
- 3 = dye penetration reaching the axial wall
- 4 = dye penetration past the axial wall

The evaluation was performed by two previously calibrated examiners and consensus was forced when disagreements occurred. Data were subjected to the Kruskal-Wallis statistical test at a confidence level of 95% ($p<0.05$).

Results

The results and statistical analysis regarding the dentin margins are described in Table 2.

The Kruskal-Wallis test revealed a significant difference at $p = 0.0044$ between Groups 1 and 3 and Groups 2 and 3. Although Group 2 performed slightly better than Group 1, no significant difference was observed.

Table 2. Observed frequency of microleakage scores, median , and statistical grouping at dentin margins.

Groups	Scores					Median	Statistical Grouping
	0	1	2	3	4		
Group 1	5	2	0	1	0	0	A
Group 2	7	0	0	1	0	0	A
Group 3	1	0	0	7	0	3	B

*Same letters indicate no significant difference (Kruskal Wallis at p = 0.0044).

Discussion

This study evaluated the influence of including a flowable composite to the adhesive layer on the microleakage at dentin margins of Class V restorations after being light cured separately or co-cured with an adhesive system. Good marginal adaptation to the tooth structure is believed to reduce marginal discoloration, secondary caries, postoperative sensitivity, and pulpal irritation related to microleakage. The shrinkage stresses of resin composites during polymerization create forces that compete with the adhesive bond, and this may disrupt the bond to cavity walls, which is one of the main causes of marginal failure and, subsequent, microleakage.

The main rationale behind the use of flowable composites is the formation of an elastic layer that may compensate for the polymerization shrinkage stresses. When comparing Group 1, used as a control, and Group 2, in which a flowable composite was used as a base material, no statistical difference could be observed. Despite the methodological and criteria differences, this result is in accordance with several studies that also demonstrated the use of a flowable composite did not influence the microleakage[10,11,12,13,14,15,16,17] but differs from other studies that demonstrated the use of flowable composites results in an improved marginal sealing.[2,3,4,5,6,7,18]

In Group 3 a thin layer of a flowable composite was co-cured with the adhesive system. This technique has been occasionally advocated as a means to improve the marginal sealing of adhesive restorations.[9] The rationale behind the use of flowable composites as filled adhesives is the dentin bonding agents once thinned prior to light curing are between 8 and 20 microns. As the oxygen inhibition layer could prevent the adequate polymerization of the adhesive, a thin layer of flowable composite may ensure this oxygen inhibition layer is blocked out prior to polymerization of the dentin bonding agent, and it also could help the establishment of the dentin bond by creating a truly elastic wall that would compensate the stress at the restoration interface. In this study the use of a flowable composite light cured simultaneously with the adhesive did not demonstrate good results nor improve the marginal sealing. This may be explained either by the displacement of the bonding agent or by a limited depth of cure of this two component layer. Despite methodological and criteria differences, the result achieved with this technique is in accordance with similar studies.[8,19,20,21]

Conclusion

1. None of the groups tested were able to totally prevent microleakage at dentin margins.
2. The adhesive systems should not be co-cured with flowable composites.

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