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Microleakage of a Self-Adhesive Class V Composite on Primary and Permanent Dentitions

Leila Shafiei, Parinaz Mojiri, Yalda Ghahraman, Vahid Rakhshan

ABSTRACT

Aim: This study aimed to evaluate the microleakage of Class V restorations filled with a 7th-generation self-adhesive composite.

Materials and methods: In 40 permanent premolars and 80 primary canines, 160 Class V cavities were prepared, which were filled with four restorative materials (n of each material = 20 permanent and 20 primary restorations): control: nonbonded composite (Heliomolar), GI: glass ionomer (Fuji IX GP), BC: bonded Heliomolar, SC: self-adhesive composite (Embrace WetBond). Dye penetration was scored 0 to 4 at 160 coronal and 160 gingival margins under 40× magnification by two examiners. The data were analyzed with Mann-Whitney U test ($\alpha = 0.01$).

Results: The mean microleakages of the materials (in the order of 'control, GI, BC, SC') at each margin-dentition (n = 20 margins) were: coronal-permanent (3.25 ± 0.72, 2.75 ± 0.72, 0.35 ± 0.59, 2.7 ± 0.73), coronal-primary (3.3 ± 0.66, 2.85 ± 0.88, 0.55 ± 0.76, 2.65 ± 1.14), gingival-permanent (3.35 ± 0.67, 0.85 ± 0.67, 2.95 ± 0.83, 1.55 ± 1.23), and gingival-primary (3.25 ± 0.72, 0.85 ± 0.59, 2.85 ± 0.89, 2.85 ± 0.93). Compared with the control microleakage at each margin-dentition (each group's n = 20 margins), BC microleakage was significantly lesser at coronal margins only ($p = 0.000$), GI microleakage was lower at gingival margins only ($p = 0.000$), and SC microleakage was smaller at gingival margins of permanent teeth only ($p = 0.000$). After combining coronal/gingival margins, only SC microleakage in primary dentition (n = 40 margins) was not significantly lesser than the control in primary teeth ($p = 0.018$); and microleakage of all other material-dentitions were lesser than corresponding control-dentitions ($p = 0.000$). Permanent and primary teeth had similar results for all material-margins ($p > 0.5$) except for SC at gingival margins ($p = 0.001$).

Conclusion: SC should be used only at gingival margins of permanent teeth.

Clinical significance: Application of self-adhesive composite should be limited to gingival margins of permanent teeth.

Keywords: Microleakage, Class V restoration, Self-adhesive composite resin, Bonded composite resin, Self-cure glass ionomer, One-bottle total-etch bonding agent.

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INTRODUCTION

Microleakage is the main cause of tooth sensitivity and the formation of secondary caries beneath restorations.[1] It may be attributed to multiple factors, such as the gap between the tooth and the restorative material, dentinal fluids, material properties such as dissolution and coefficient of thermal expansion, polymerization shrinkage, shape of the cavity and methods of the placement of the material.[2,3] It may cause pulpitis in vital teeth due to bacteria toxins, and may reduce restoration longevity because of bacteria colonization through the restoration-tooth gap or in dentinal tubules.[1,3,4] After the introduction of bonding materials, a lot of effort was devoted to improving the properties of these materials in terms of minimizing the microleakage, technique-sensitivity and the number of clinical stages as well as improving the adhesion rates and the convenience of manipulation.[5] However, the presence of microleakage through the adhesive-tooth junctions is still a main cause of restoration replacements.[6,7]

Class V lesions and cavities are usually difficult to access, therefore, choosing the appropriate restorative material might be a challenge.[5] Obviously, the use of materials with high bonding capacities and less clinical stages may be more favorable in these cavities. In this regard, new generations of materials are marketed frequently, including self-etching composites (6th generation)[8] and self-adhesive composites (7th generation).[9] Unlike self-etching adhesives which still must be bonded, the self-adhesive composites are capable of simultaneously etching, priming, and bonding to the enamel or dentin surfaces, which enable the clinician to only rinse/dry the cavity and then place the composite.[5,9,10]

Considering the significance of the microleakage as a major cause of restoration failure, knowing this trait of novel generations of restorative materials seems to be necessary for choosing between available alternatives depending on dentists' clinical priorities and limitations. To our knowledge, while only few studies have evaluated the microleakage of self-adhesive composites used as luting cements,[11,12] the literature lacks any studies on the microleakage of these composites used as direct restoration materials. Therefore, this study aimed to compare the microleakage of a self-adhesive composite at gingival and coronal margins of class V restorations placed in primary and permanent teeth, with the microleakages at the same margins of similar class V cavities filled with a control and two common restorative materials.

MATERIALS AND METHODS

This experimental *in vitro* study was performed on 320 margins of 160 class V restorations prepared in 120 teeth (80 intact primary canines and 40 permanent premolars) which had been extracted for orthodontic purposes from patients without any histories of bleaching. The specimens were evaluated under 10× magnification to meet the inclusion criteria, which were the absence of any caries, fractures, restorations, hypomineralization and hypocalcification. After debriding and then storing the specimens in 0.1% thymol solution for 48 hours, they were stored in normal saline at room temperature (in less than 3 months) until restoration.

Cavity Preparation

With the use of a high-speed diamond bur (Tiz Kavan, Iran), class V cavities were prepared on the buccal surfaces of primary canines, as well as on both buccal and lingual surfaces of permanent premolars. The cavities were 3 mm in mesiodistal width, 2.5 mm in occlusogingival height, and 1.5 mm in axial depth. The coronal margin was located on the enamel, while the gingival margin was 1 mm under cementoenamel junction (CEJ). The finish lines were butt joint. After preparing every 5 cavities, the used bur was replaced with a new one.

Restoration

The sample was divided to four groups of n = 40 cavities each (20 cavities in permanent teeth and 20 cavities in primary teeth):

Microfilled composite placed without bonding agent (Control): After rinsing and air-drying each specimen with an oil-free air/water syringe, the cavity was filled with a microfilled composite (Heliomolar, Ivoclar/Vivadent, Liechtenstein) without the application of etching and bonding agents. The composite was placed in two increments, each of which was light cured for 40 seconds, using a calibrated light-curing unit (BluePhase C8, low power, 470 nm, Ivoclar/Vivadent, Liechtenstein).

Self-cure glass ionomer (GI): The cavity was thoroughly rinsed and air-dried. The self-cure glass ionomer (Fuji IX GP, GC America, USA) was blended according to the manufacturer's instructions. Afterward, the material was placed in the cavity, and it was sealed with a layer of petrolatum.

Microfilled composite placed with a total-etch bonding agent (BC): The cavity was etched (15 s) with a 37% phosphoric acid gel (Ivoclar/Vivadent), and then was water sprayed (15 s). The excess moisture on the dentin was removed with a cotton ball (the wet bonding technique). Using a disposable microbrush, a thin layer of a 5th generation single-bottle total-etch bonding agent (Excite, Ivoclar/Vivadent) was applied to the cavity surfaces. It was gently air blown for 5 seconds, and a second layer of bonding agent was applied and was light cured for 40 seconds. The microfilled composite was placed as two increments, each of which was light cured for 40 seconds.

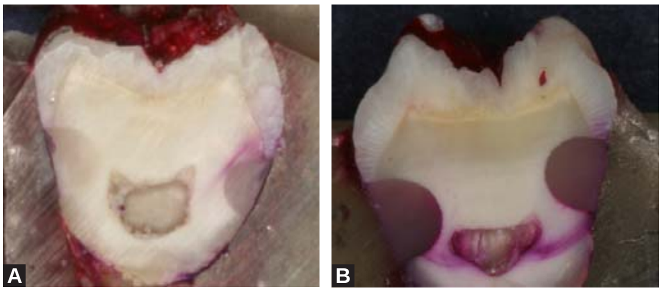
Self-adhesive composite (SC): According to the manufacturer, after rinsing and drying the cavity (wet bonding technique), it was filled with the self-adhesive composite (Embrace WetBond Class V, Pulpdent, USA) and was light cured for 20 seconds.

Thermocycling

The specimens were stored in distilled water at 37°C for 36 hours. Afterward, the restorations were polished using a carbide bur (Tiz Kavan) and the teeth were subjected to thermocycling procedures (2,000 cycles, 5-55°C, dwell time = 30 s, transfer time = 15 s).

Determination of the Microleakage

The root apices were sealed with sticky wax. Two layers of nail polish were applied to all surfaces of each tooth except a 1 mm margin around the restoration. Then the teeth were stored in 0.5% fuchsine solution at neutral pH for 4 hours at room temperature. After cleaning and air-drying the teeth, using a diamond disk (Tiz Kavan), they were sectioned buccolingually through the middle of mesiodistal width of the restoration (one section, Figs 1A and B). Two experienced examiners independently evaluated the extent of infiltrated dye at both coronal and gingival margins of each section,



Figs 1A and B: Representative photographs of two permanent premolar sections (A) with a high leakage through the coronal margin (B) and a high leakage through the gingival margin

under 40× magnification. Based on the extent of dye penetration, the microleakage was scored 0 to 4:[13] 0 = no dye penetration; 1 = dye penetration to the 1/3rd of the preparation depth; 2 = greater than 1/3rd and up to 2/3rd of axial depth; 3 = greater than 2/3rd and up to the preparation depth; 4 = greater than the preparation depth.

There was 92% inter-rater agreement (Cohen's Kappa = 0.92, p = 0.000). After 1 week, the scores of the two examiners were compared, and both of the examiners together re-evaluated restorations with inconsistent microleakage scores.

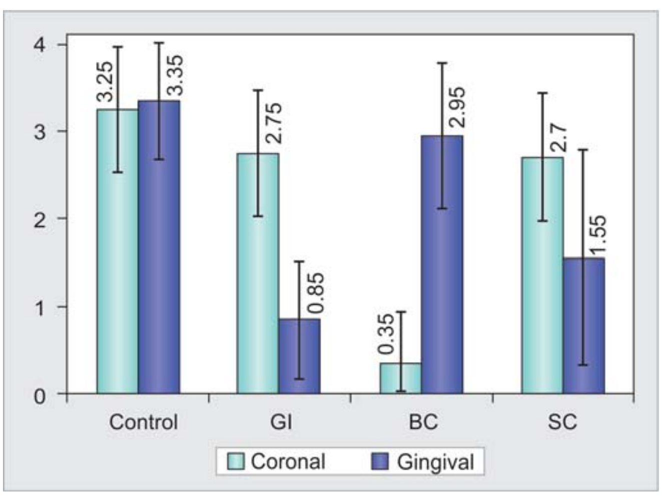
STATISTICAL ANALYSIS

Mean and frequency distributions of microleakage scores were calculated. The data were analyzed with a Mann-Whitney U test. The level of significant was set at 0.01.

RESULTS

Microleakage in Permanent Dentition

The mean microleakage scores of nonbonded composite (control), GI, BC and SC materials were 3.30 ± 0.69, 1.80 ± 1.18, 1.65 ± 1.5, 2.13 ± 1.16, respectively (Graph 1).



Graph 1: Mean and standard deviations of microleakage scores in permanent teeth

According to the Mann-Whitney U test, the microleakage of the control group [both gingival and coronal margins (n = 2 × 20)] was significantly higher than the microleakage of each of the experimental groups (each p-value = 0.000).

There were significant differences between gingival and coronal microleakage scores of each experimental group (Table 1).

Microleakage in Primary Dentition

The mean microleakage scores of control, GI, BC and SC materials were 3.28 ± 0.68, 1.85 ± 1.25, 1.70 ± 1.42, and 2.75 ± 1.03, respectively (Graph 2). The mean microleakage of the control group (n = 2 × 20 margins) was significantly higher than that of GI (p = 0.000) and BC (p = 0.000), but was not significantly higher than SC microleakage (p = 0.018).

There were significant differences between gingival and coronal leakages of glass ionomer and BC, but not SC (Table 2).

Microleakage through each Margin-Dentition

Coronal Margins of Permanent Teeth

On coronal margins of permanent teeth, the mean microleakage of control composite (n = 20 margins) was significantly higher than BC (p = 0.000), however it was not significantly greater than microleakages of GI (p = 0.038) and SAP (p = 0.026). The Mann-Whitney U test showed that BC microleakage was significantly lesser than microleakages of both GI (p = 0.000) and SC (p = 0.000). However, there was not a significant difference between microleakages of GI and SC (p = 0.806, Graph 1).

Coronal Margins of Primary Teeth

The mean microleakages at coronal margins of primary teeth were similar to that of permanent teeth. The control microleakage (n = 20) was significantly higher than BC microleakage (p = 0.000), but not significantly higher than that of GI (p = 0.080) and SC (p = 0.049). The BC microleakage was significantly lesser than microleakages of both GI (p = 0.000) and SC (p = 0.000). There was a nonsignificant difference between GI and SC (p = 0.601, Graph 2).

Gingival Margins of Permanent Teeth

The control microleakage (n = 20) was significantly higher than microleakages of GI (p = 0.000) and SC (p = 0.000), but it was not significantly higher than BC microleakage (p = 0.119). At these margins, the GI microleakage was the

Table 1: Frequency distribution of microleakage across the groups of permanent teeth

Groups		*n*	*Distribution (%)*					*p-value*
			0	*1*	*2*	*3*	*4*	
Control	Occlusal	20	0	0	15	45	40	0.883
	Cervical	20	0	0	10	45	45	
Glass ionomer	Occlusal	20	0	5	25	60	10	0.000
	Cervical	20	30	55	15	0	0	
BA composite	Occlusal	20	70	25	5	0	0	0.000
	Cervical	20	0	5	20	50	25	
SA composite	Occlusal	20	0	5	30	55	10	0.001
	Cervical	20	25	20	40	5	10	

In each group, the occlusal and cervical microleakage is compared using the Mann-Whitney U test

Table 2: Frequency distribution of microleakage across the groups with primary teeth, as well as mean of the frequencies

Groups		*n*	*Distribution (%)*					*p-value*
			0	*1*	*2*	*3*	*4*	
Control	Incisal	20	0	0	10	50	40	0.883
	Cervical	20	0	0	15	45	40	
Glass ionomer	Incisal	20	5	0	15	65	15	0.000
	Cervical	20	25	65	10	0	0	
BA composite	Incisal	20	60	25	15	0	0	0.000
	Cervical	20	0	10	15	55	20	
SA composite	Incisal	20	10	0	25	45	20	0.678
	Cervical	20	0	10	20	45	25	

The microleakage distribution is compared on incisal and cervical margins, using Mann-Whitney U test

Table 3: Comparing frequency distribution (%) of microleakage scores of groups of primary and permanent teeth, using Mann-Whitney U test

Groups		*n*	*Distribution (%)*					*p-value*
			0	*1*	*2*	*3*	*4*	
Control	Permanent	40	0.0	0.0	12.5	45.0	42.5	0.853
	Primary	40	0.0	0.0	12.5	47.5	40.0	
Glass ionomer	Permanent	40	15.0	30.0	20.0	30.0	5.0	0.865
	Primary	40	15.0	32.5	12.5	32.5	7.5	
BA composite	Permanent	40	35.0	15.0	12.5	25.0	12.5	0.858
	Primary	40	30.0	17.5	15.0	27.5	10.0	
SA composite	Permanent	40	12.5	12.5	35.0	30.0	10.0	0.428
	Primary	40	5.0	5.0	22.5	45.0	22.5	

lowest. The difference between GI with SC microleakages was not significant (p = 0.052); and the BC microleakage was significantly higher than microleakages of both GI (p= 0.000) and SC (p = 0.000, Graph 1).

Gingival Margins of Primary Teeth

At gingival margins of primary teeth, the control microleakage (n = 20) was significantly higher than GI microleakage (p = 0.000), however it was not significantly higher than microleakages of BC (p = 0.154) and SC (p = 0.182). GI microleakage was significantly lower than microleakages of both BC (p = 0.000) and SC (p = 0.000). However, microleakages of BC and SC were similar (p = 1, Graph 2).

Permanent *vs* Primary

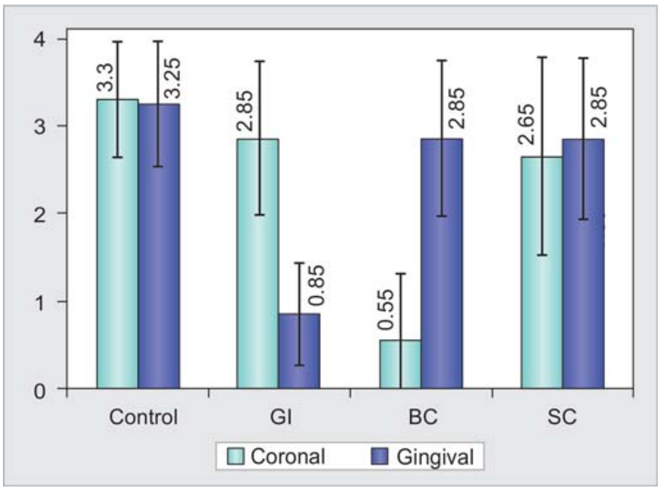
In overall and combining the microleakage scores of coronal and gingival margins, all materials acted similarly in permanent and primary teeth (Table 3).

Coronal Margins

The microleakage of the materials did not significantly differ at coronal margins of permanent teeth compared with primary teeth (each of the four p-values > 0.5).

Gingival Margins

In microleakage scores of gingival margins, only SC microleakages differed significantly in permanent and



Graph 2: Mean (SD) microleakage scores in primary teeth

primary teeth (p = 0.001) and the results of other materials were similar in primary and permanent teeth (all three p-values > 0.7).

DISCUSSION

The findings of the present study showed that the bonded composite and the glass ionomer might be regarded as the materials of choice at enamel and dentin margins, respectively. The results of the self-adhesive composite were something between the results of these two materials, with a more inclination to glass ionomer results at three out of four margin types. In most of the cases, there were similarities between results drawn from permanent or primary dentitions, which was consistent with the literature.[14,15] Also all of the materials (except SC in primary teeth) showed significant differences between the extent of microleakage at gingival and coronal margins of both primary and permanent teeth; supporting the results of certain similar studies.[14] Furthermore, the application of bonding agent in this study was shown to have a substantial impact on the bond of composite, as was reported previously.[16]

Compared with the control group, the bonded composite significantly reduced the microleakage at coronal margins. However, glass ionomer and self-adhesive composite failed to do so. This was in harmony with the findings of certain other studies.[10,17] Due to the high mineral content of the enamel as well as its crystal structure, enamel etching may efficiently alter its surface profile, increasing the number and depth of micropores, strengthening the interlocking between enamel and adhesive tags, and reducing the gap size and microleakage.[18,19] However, at dentinal margins, the bonded composite had the poorest results. Due to its organic matrix and having a lower fraction of mineralized content, dentin is naturally wet which may interfere with the bonding mechanisms with a hydrophobic material.[16,17] Therefore, the bond strength of composite resin to dentin may be weaker.[10,16]

In this study, compared with the bonded composite resin, a higher mean microleakage was observed at the enamel margins of glass ionomer restorations. A chemomechanical adhesion to the mineralized substrate might contribute to the bonding of glass ionomers.[15,20] The polyacrylic acid in the glass ionomer has a high molecular mass and a moderate acidity. Therefore, its enamel etching capacity is less, especially in the presence of smear layer.[21] The glass ionomer may not remove the smear layer,[21] which might lead to a weaker bond strength. At dentin margins however, the glass ionomer showed the lowest microleakage. Its hydrophilic nature (adjacent to the moist dentin), as well as its chemical bond to dentin (with the calcium chelation mechanism), may explain this finding.[15]

The present study showed that similar to the glass ionomer, the self-adhesive composite might not adhere well to the enamel, confirming the results of certain similar studies on self-etching [9] and self-adhesive luting cements[22] in terms of bond strength. De Munk et al[9] (2004) evaluated the surface penetration of a self-adhesive cement with scanning electron microscopy and concluded that it established a poor bond to the tooth surface. Certain factors may contribute to the lower efficacy of these materials on enamel, including insufficient enamel etching, remained smear layer under self-adhesive composite, probable hygroscopic expansion of the hydrophilic acidic resin which might increase the hydrolysis likelihood, and the higher viscosity of these materials compared to that of the bonding agents.[12,23] Despite these evidences, Behr et al[11] showed that different brands of self-adhesive luting cement materials might show contrasting results on enamel and dentin, implying that the details of manufacturing procedures might be of more significance to product properties compared to the generation of these materials, although further studies are necessary to assess this. At both enamel margins and at one of dentin margins, SC acted like GI. Some explanations for the similarity between the results of these two at three margins might be their similar properties in terms of their chemical bond to dentin,[10] hydrophilic nature, lack of perfect enamel etching,[12] and their inability to remove the smear layer.[21]

While the self-adhesive composite reduced the microleakage at gingival margins of permanent teeth, it failed to produce similar results at gingival margins of primary teeth. There are some differences between permanent and primary tooth tissues such as the thinner dentin and tubule density/diameter in primary teeth, as well as the possibility that primary dentin is chemically more reactive to acidic conditioners, which might reduce the efficacy of etching in these teeth.[15] Nevertheless, in case this inconsistency was due to such natural differences, similar findings would be observed in the other studied materials as well. Considering the uniformity of the results of other groups, this inconsistency was unlikely to be due to study errors. The chemical formula of this material was not available for further discussions.

In overall and regardless of the margin types (coronal/gingival), the experimental materials showed appropriate results in both dentitions compared to the control (except SC in primary teeth). Nonetheless, focusing at each margin-dentition and comparing coronal and gingival margins for each material showed that those materials which were appropriate for one margin (i.e. coronal or gingival) would show microleakage at the other margin. This might be due to the polymerization shrinkage stresses which might cause a debond from the weakest bonding surface. Apparently, the self-adhesive composite had limited bond to both enamel and dentin in primary teeth which showed leakage at both margins.

This study was limited by some factors. A greater number of dye penetration scores might increase the accuracy of the results, although it might increase the risk of measuring error as well. The type of disinfectant material used and the duration of the disinfection procedure, and the method of sealing the root apices might act as confounding variables. Moreover, fuchsine solution differs in viscosity and other characteristics from those of saliva; and the setting and maturation of the self-cure glass ionomer might depend on some *in vivo* conditions such as temperature, moisture or ion interactions with saliva, which were not present during its setting procedure in this study. Finally, masticatory forces which may increase the marginal gaps[3] were absent in this *in vitro* study. However, the authors tried to increase the validity and reliability of the results by sampling a large number of human permanent and primary teeth, scoring dye penetration by two experienced observers, adopting two methods of aging, and preparing the sample in a short time which was important for maintaining normal characteristics of tooth tissues.[3]

CONCLUSION

Within the limitations of this *in vitro* study, the self-cure glass ionomer and light-cure bonded composite were promising only for dentin and enamel margins, respectively. The self-adhesive showed appropriate results only at dentinal margins of permanent teeth.

Permanent and primary teeth showed similar results for all material-margins except self-adhesive composite at dentinal margins which showed contradictory results in permanent and primary dentitions.

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