Microleakage of Different Restorative Materials in Class V Restorations: In-Vitro Study

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Abstract: ***Microleakage is a major factor contributing in the occurrence of secondary carious lesions around restorations. This study aimed to evaluate the microleakage around class V restorations using different restorative materials. In this in vitro study, 32 standardized class V cavities were prepared on buccal and lingual surfaces of 16 human teeth (extracted within a period of 6 months) using bevelled conventional preparation, where occlusal margin was located at the enamel and cervical margin at the cementum/dentin level. Specimens were randomly divided into 4 groups (N= 8) for restoration with (A) GC Fuji II LC (Resin modified glass ionomer) (B) Prime&Bond universal + SDR plus (Smart dentin replacement) (C) FuturaU Bond + Admira Fusion Flow (Ormocer-based nanohybrid flowable composite) (D) Palfique universal bond + Palfique universal flow. After being stored in distilled water and finished, teeth were immersed for 24 hours in 2% methylene blue dye. Teeth were sectioned bucco-lingually and dye penetration on occlusal and cervical margins was scored using a stereomicroscope. The results were analyzed using Chi square test and Kruskal-wallis test (a = 0.05). There was statistical significant difference between microleakage at occlusal margin and at the cervical margin (p < 0.001). None of the four different groups of restorative materials completely sealed the tooth/restoration interface at the cervical margin showing no statistical significant difference in microleakage (p = 0.054), while there was a statistical significant difference between the different materials at the occlusal margin (p = 0.024). When comparing different restorative materials in Class V cavities, the cervical margins, where adhesion is between restorative material and dentin/cementum, showed the greatest scores in microleakage (1).***

Keywords: Flowable composite, microleakage, resin modified glass ionomer, class V restorations

1. Introduction

One of the most widely prevalent disease problems in today's dentistry is dental caries. And it has been proven that recurrent caries is the major complication following dental restorations (2). The loss of tooth structure, which results from dental caries, affects tooth shape and function. This damage can be restored with a wide range of restorative materials. Each one of them has its advantages and disadvantages; hence, proper selection will facilitate the daily practice of the clinician and will help to achieve clinical success. The resin-modified glass ionomer was introduced in 1988, after nearly sixteen years of introduction of conventional glass ionomer cement in 1972, in an attempt to overcome its drawbacks such as; low mechanical strength, impaired translucency as well as moisture sensitivity. The handling properties and aesthetics were improved in addition to increase in working time through adding polymerizable hydrophilic resin to conventional glass ionomer formulations (3, 4). Glass ionomer is considered the material of choice in non-carious cervical lesions and root caries (5). In the age of aesthetic dental adhesives, dental resin composites became the most frequently used for replacing lost tooth structure as a result of dental decay. Resin composite restorative materials combine aesthetics with adequate physical and mechanical properties. In the mid-90s, flowable resin composite was introduced with its low viscosity and high flowability enabling the material to closely adapt to cavity walls and floor and consequently enhancing tooth/restoration union resistance (6, 7).

Marginal seal, the ability to prevent bacterial penetration at the restoration/tooth interface, is a crucial factor affecting the longevity of the restorative materials. The presence of microgaps (10-6 μm) at restoration/tooth interface will allow microorganisms, fluids, molecules, and ions to penetrate through. This clinically undetectable microleakage results in postoperative sensitivity, recurrent caries and may cause pulp injury. A low microleakage score of a certain restorative material indicates a long survival rate in the oral cavity (6, 8).

In class V cavities, there is difficulty in achieving proper marginal adaptation, especially at the cervical margins, where there is little or no enamel. The cervical margin comes in direct contact with cementum. That's why adhesion decreases considerably at cervical margins, as adhesion of restorative materials to enamel is much better compared to dentin or cementum surfaces (6, 9).

This in-vitro study was conducted to evaluate the microleakage around class V restorations (occlusal and cervical margins) using resin-modified glass ionomer and different flowable resin composite restorative materials. This study was designed to test the null hypothesis of that there was no difference in microleakage between different restorative materials at occlusal and cervical margins.

2. Material and Method

In this study, 16 freshly extracted molars free from caries, cracks, and restorations were collected; then, cleaned from debris, disinfected with 0.5% thymol solution, and finally stored in saline solution at room temperature to avoid dehydration before the restorative procedure and testing.

In each molar, 2 class V cavities were prepared in the buccal and lingual surfaces with the occlusal margins located at

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enamel, while the cervical margins located 1.5 mm apical to cemento-enamel junction at the cementum/dentin level. Cavity dimensions were standardized using a template of 4.0 mm width, 3.0 mm height, and 1.5 mm depth using a carbide ball-shaped bur, changed every 4 cavities, with a cooled high speed hand-piece (Fig.1). Cavities were bevelled on the occlusal margins only, 0.5 mm wide bevel at a 45° on enamel. Finally, they were finished using low speed hand-piece (6).

Figure 1: Standardized class V cavity preparation [width= 4 mm, height= 3 mm, depth= 1.5 mm] prepared using carbide ball-shaped bur changing every 4 cavities with a cooled high speed hand-piece

The specimens were randomly divided into 4 groups, each group contains 8 class V cavities on the buccal and lingual surfaces of 4 molars and then restored according to manufacturer recommendations. Group A were restored with GC Fuji II LC (resin-modified glass ionomer), group B were restored with Prime&Bond universal + SDR plus (smart dentin replacement), group C were restored with FuturaU Bond + Admira Fusion Flow (ormocer-based nanohybrid flowable composite), and group D were restored with Palfique universal bond + Palfique universal flow (Fig.2). After that, the specimens were immersed in distilled water at 37°. After 24 hours, restorations were finished and polished using Sof-Lex™ discs (3M Dental Products, st. Paul, MN55144, USA) (6).

Figure 2: (1) GC Fuji II LC, (2) SDR Plus, (3) Admira Fusion Flow, (4) Palfique universal flow

Specimens were covered with 2 layers of nail varnish all around except for 1 mm around the class V restorations, where there is no Nail Varnish. Apical foramen received 4 layers of nail varnish to avoid any kind of penetration toward the pulp (Fig.3). Teeth were immersed in 2% methylene blue solution away from sunlight for 24 hours, then cleaned and washed under tap water for 5 minutes (10, 11).

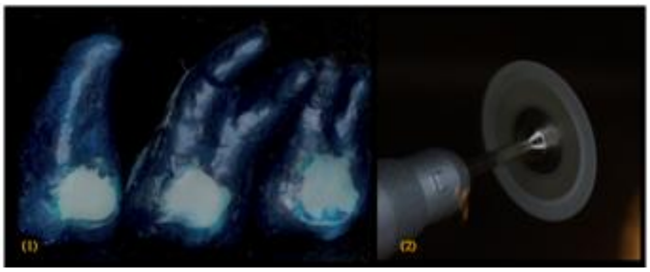


Figure 3: (1) Specimens were covered with 2 layers of Nail Varnish all around while for Apical foramen where 4 layers were added except for 1 mm around the class V restorations, where there is no Nail Varnish (2) Using Carborundum Disc to make a bucco-lingual sectioning of specimens

The specimens were longitudinally sectioned through the middle of restorations in a bucco-lingual plane using a water-cooled diamond saw at a slow speed (Fig.3). Each specimen was divided into 2 equal sections, which were finished, cleaned, and finally analyzed for microleakage. The cut sections were observed under Leica S8APO stereomicroscope (Wetzlar, Germany) at 20× magnification (Figs.4, 5, 6, and 7). The microleakage, marginal infiltration of the methylene blue dye, was evaluated at occlusal and cervical margins of each specimen using standardized numeration/scoring (6, 8, 12).

Score 0: No dye penetration;
Score 1: Dye penetration less than 1/3 of the cavity walls;
Score 2: Dye penetration less than 2/3 of the cavity walls;
Score 3: Dye penetration more than 2/3 of the cavity walls without axial wall involvement;
Score 4: Dye penetration to the full extent of the cavity wall, reaching the axial wall or penetrating it.

Statistical analysis was carried out using SPSS software version 22 (SPSS Inc., Chicago, IL, USA). The results were analyzed through Chi-square test and Kruskal-wallis test at a significance level of 0.05 (α = 0.05) (tables 1, 2, and 3).

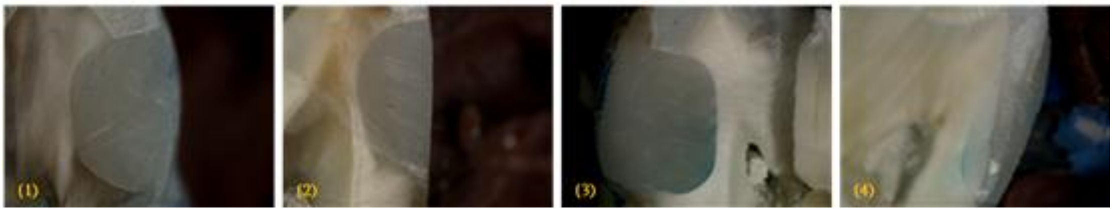


Figure 4: Stereomicroscopic pictures of Group (A) GC Fuji II LC (Resin modified glass ionomer): (1) (2) Score 0 at the occlusal and gingival margin, (3) (4) Score 4 at the gingival margin

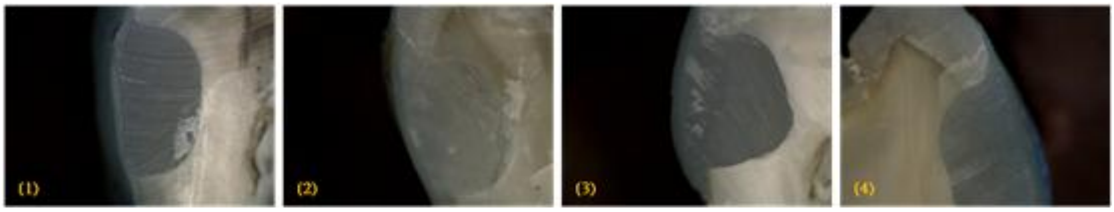


Figure 5: Stereomicroscopic pictures of Group (B) Prime&Bond universal + SDR plus: (1) (2) (3) Score 0 at the occlusal and gingival margin, (4) Score 1 at both occlusal and gingival margin

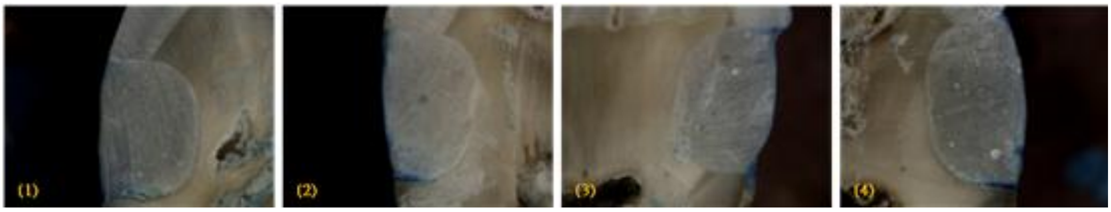


Figure 6: Stereomicroscopic pictures of Group (C) FuturaU Bond + Admira Fusion Flow: (1) Score 1 at the occlusal and Score 3 gingival margin, (2) Score 1 at the occlusal margin and 2 at the gingival margin, (3) Score 2 at the occlusal margin and 1 at the gingival margin, (4) Score 1 at the occlusal margin and 3 at the gingival margin

Figure 7: Stereomicroscopic pictures of Group (D) Palfique Universal Bond + Palfique Universal Flow: (1) Score 0 at both occlusal and gingival margin, (2) Score 4 at the gingival margin and 1 at the occlusal margin, (3) Score 0 at both occlusal and gingival margin

3. Results

Chi-square test revealed that there was statistically significant difference between microleakage at the occlusal margin and at the cervical margin ($p < 0.001$). None of the four tested groups of restorative materials completely sealed the tooth/restoration interface at the cervical margin showing no statistically significant difference in microleakage ($p = 0.054$) (tables 1), while there was a statistically significant difference between the different materials at the occlusal margin ($p = 0.024$), where group (C) showed the highest scores in microleakage at the occlusal margins, while the least microleakage scores were obtained from the group (A, and D) without significant difference between them (tables 2, and 3) (1).

Table 1: Chi-Square Test (Materials * GINGIVALSCORING Crosstabulation)

Materials * GINGIVALSCORING Crosstabulation

			GINGIVALSCORING 0	1	2	3	4	Total
Materials	Admira Fusion Flow	Count	2	1	2	3	0	8
		Expected Count	4.8	1.0	.5	1.0	.8	8.0
	GC Fuji II LC	Count	6	0	0	0	2	8
		Expected Count	4.8	1.0	.5	1.0	.8	8.0
	Palfique U. Flow	Count	4	2	0	1	1	8
		Expected Count	4.8	1.0	.5	1.0	.8	8.0
	SDR PLUS	Count	7	1	0	0	0	8
		Expected Count	4.8	1.0	.5	1.0	.8	8.0
Total		Count	19	4	2	4	3	32
		Expected Count	19.0	4.0	2.0	4.0	3.0	32.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	20.772ᵃ	12	.054
Likelihood Ratio	22.805	12	.029
N of Valid Cases	32		

a. 20 cells (100.0%) have expected count less than 5. The minimum expected count is .50.

There is no statistical significant difference as the Asymptotic Significance (2-sided) = 0.054, more than the designated alpha level (normally 0.05)

Table 2: Chi-Square Test (Materials * OCCLUSALSCORING Crosstabulation)

Materials * OCCLUSALSCORING Crosstabulation

			OCCLUSALSCORING			Total
			0	1	2	
Materials	Admira Fusion Flow	Count	2	4	2	8
		Expected Count	5.8	1.8	.5	8.0
	GC Fuji II LC	Count	8	0	0	8
		Expected Count	5.8	1.8	.5	8.0
	Palfique U. Flow	Count	7	1	0	8
		Expected Count	5.8	1.8	.5	8.0
	SDR PLUS	Count	6	2	0	8
		Expected Count	5.8	1.8	.5	8.0
Total		Count	23	7	2	32
		Expected Count	23.0	7.0	2.0	32.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	14.609ª	6	.024
Likelihood Ratio	15.898	6	.014
N of Valid Cases	32		

a. 8 cells (66.7%) have expected count less than 5. The minimum expected count is .50.

There is statistical significant difference as the Asymptotic Significance (2-sided) = 0.024, less than the designated alpha level (normally 0.05)

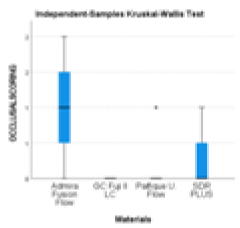
Table 3: Kruskal-Wallis Test

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of OCCLUSALSCORING is the same across categories of Materials.	Independent-Samples Kruskal-Wallis Test	.004	Reject the null hypothesis.
2	The distribution of GINGIVALSCORING is the same across categories of Materials.	Independent-Samples Kruskal-Wallis Test	.096	Retain the null hypothesis.

a. The significance level is .050.

b. Asymptotic significance is displayed.

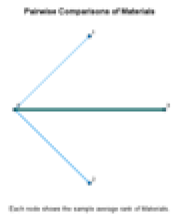


Pairwise Comparisons of Materials

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.ª
GC Fuji II LC-Palfique U. Flow	-1.875	3.689	-.508	.611	1.000
GC Fuji II LC-SDR PLUS	-3.750	3.689	-1.017	.309	1.000
GC Fuji II LC-Admira Fusion Flow	12.375	3.689	3.355	.001	.005
Palfique U. Flow-SDR PLUS	-1.875	3.689	-.508	.611	1.000
Palfique U. Flow-Admira Fusion Flow	10.500	3.689	2.846	.004	.027
SDR PLUS-Admira Fusion Flow	8.625	3.689	2.338	.019	.116

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .050.

a. Significance values have been adjusted by the Bonferroni correction for multiple tests.



4. Discussion

In clinical dentistry, microleakage is one of the factors affecting the success of dental restorative materials (13). It is defined as the penetration of bacteria through microgaps at the restoration/tooth interface (14). In this study, U-shaped cavity preparations were cut on the buccal and lingual surfaces of each molar using carbide bur. U-shaped class V cavities were proven to be superior to V-shaped cavities in reducing microleakage. Cavity margins were positioned on enamel occlusally and cementum/dentin cervically 1.5 mm from the CEJ with bevelling only on enamel interfaces occlusally. Methylene blue dye was used for microleakage test as each dye molecule has 0.80 nm in diameter which is lesser than dentinal tubule diameter (1-4 μm) (15). The influence of thermal cycling (aging) was always a conflicting topic between authors. Based on several papers published demonstrating that it has no effect on dye penetration and microleakage of restorative materials (16-22), thermocycling process was not performed in the present study. A conventional sectioning (single longitudinal at the midline) was used, despite the fact that microleakage was not found to be the same along all restorative margins and three-dimensional evaluation gave more accurate results. The three-dimensional evaluation is user sensitive, time consuming and not easy technique (22).

In this study, we compared between microleakage scores at occlusal and cervical margins of each restorative material. Considering the limitations of this in-vitro study, results reject the null hypothesis which presumed that there is no difference in microleakage between different restorative materials at occlusal and cervical margins. All restorative materials had greater microleakage scores at the cervical margins where there is little or no enamel, which agrees with the results of Puckette et al (23) and Gupta et al (24). Adhesion of resin composite restorations with dentin at the cervical margin is not as strong as with enamel at the occlusal margin because dentin has higher organic content, fluid pressure and lower surface energy (8). Consequently, resin composite restorations tend to be dislodged occlusally during polymerization contraction resulting in poor adaptation at the cervical margin (9, 25). Resin-modified glass ionomer restorations showed lesser microleakage at cervical margins in comparison with resin composites, which agrees with the results of Farmer et al (26).

5. Conclusion

None of the tested restorative materials completely sealed the cervical margins; however, there was a significant difference between the restorative materials in sealing the occlusal margins. Flowable resin composite restorations showed better sealing with enamel occlusally, while resin-modified glass ionomer restorations had lesser microleakage with dentin/cementum cervically.

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