

Original Article

An *in vitro* microleakage study of class V cavities restored with a new self-adhesive flowable composite resin versus different flowable materials

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ABSTRACT

Background: Regarding the importance of sealing ability of restorative dental materials, this study was done to assess the microleakage of class V cavities restored with a new self-adhesive flowable composite resin and compare to different flowable materials.

Materials and Methods: Seventy standardized class V cavities were prepared on the buccal surface of maxillary premolars teeth. The occlusal and the gingival margins of the cavities were located on the enamel and cementum/dentin, respectively. Teeth were randomly assigned into five groups ($n = 14$) and restored with different flowable materials following the manufacturer's instructions: groups I and II: EMBRACE WetBond flowable composite resin with and without acid etching and bonding agent, respectively; group III: flowable compomer (Dyract Flow); and IV and V: microhybrid (Tetric Flow) and nanofilled (Premise Flowable) flowable composite resins, respectively. After finishing and polishing, the teeth were stored in distilled water at 37°C, thermocycled, coated with nail varnish, and immersed in a basic fuchsin, and then longitudinally sectioned. Dye penetration was examined with a stereomicroscope and scored separately for occlusal and gingival on a 0-3 ordinal scale. Data were analyzed with Kruskal-Wallis, Mann-Whitney and Wilcoxon tests ($\alpha=0.05$).

Results: EMBRACE WetBond with acid etching and bonding agent had significantly less microleakage at the occlusal margins than those without, but not at cervical margins. Also cavities restored with EMBRACE WetBond without acid etching and bonding agent showed significantly greater microleakage scores than other groups at occlusal margin, but there was no significant difference at the cervical margin.

Conclusion: The application of acid etching and bonding agent with EMBRACE WetBond provided better occlusal marginal sealing than those without at class V cavities.

Key Words: Class V cavities, flowable compomer, flowable composite resin, microleakage

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INTRODUCTION

Cervical lesions are very often caused by incorrect toothbrushing and dental caries, and usually have little or no enamel at the cervical margin.^[1] Flowable composite resins are widely used in clinical practice and are the most common resin materials that

recommend for restoring these lesions instead of conventional resin composites. These materials have good aesthetic properties, and because of low viscosity,^[2-4] are easier to place and more self-adaptable compared to stiffer restorative materials.^[5,6] Also, flowable materials may act as a stress-breaker; therefore, they have been advocated as a gingival liner in class II composite resin restorations.^[5,7,8]

The flowable composite resins due to their lower filler content have higher polymerization shrinkage, coefficient of thermal expansion,^[9,10] and inferior mechanical properties.^[4] Stresses from shrinkage create forces that compete with the adhesive bond, and this may disrupt the bond to cavity walls, which

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is still one of the main causes of marginal failure and subsequent microleakage.^[9-11] Moreover, in cervical lesions, the lack of enamel at the gingival margin aggravates the situation.^[12] However, the importance of perfect seal for success and longevity of class V resin restorations must be considered at the time of restorative treatment.^[3,13] Miyasaka and colleagues found that the shrinkage ratio was less than 1.5% in the conventional composites, but more than 2.0% in the flowable ones.^[2] Nevertheless, some studies showed that flowable composite resins produced polymerization contraction stress similar to the hybrid composite.^[14,15]

With passing of time, new materials and techniques have been developed for tooth restoration to facilitate the daily practice of clinicians. A new self-adhesive flowable composite resin was introduced. This material is an alternative to the time-consuming procedure used with traditional materials. The EMBRACE WetBond (Pulpdent Corporation, MA, USA) is a flowable composite resin and the first moist-bonding restorative resin specifically designed for cervical restorations, where it is often difficult to achieve perfect isolation from moisture. It is formulated with an advanced, hydrophilic, Resin Acid-Integrating Network (R.A.I.N.), and self-adhesive, forming chemical and micromechanical bonds to the tooth structure. Therefore, bonding agents and etching dentin are not required. It releases fluoride and has a translucent quality providing excellent aesthetics in the vast majority of situations.^[16]

The current flowable composite resins are used along with acid etching and bonding agent routinely. Since cervical lesions are extended to different bonding substrates, enamel at the occlusal and dentin at the gingival margins, bonding of resins to dentin is more difficult and less predictable than bonding to enamel. Hence, complete penetration into the entire depth of the demineralized zone and obtaining a reliable bonding is essential to prevent bacterial microleakage and recurrent caries,^[10,17,18] although some researchers concluded that there was no difference in occlusal or cervical microleakage of cavities restored with flowable or hybrid composite resins.^[15,19] Thus, if a new resin material can be substituted in the application of acid etching and the bonding agent achieves a strong and durable cohesive bond with enamel and dentin, it will be a new change in esthetic dentistry.

To the best of our knowledge, there is limited documentation regarding EMBRACE WetBond. Considering the seriousness of the case, the present study was conducted with the aim of evaluating and comparing the microleakage of class V cavities restored with new self-adhesive flowable composite resin versus different flowable materials and the null hypothesis was that these materials have no difference effect on microleakage.

MATERIALS AND METHODS

A total of 70 freshly human maxillary first premolars without decay, cracks or previous restorations extracted for orthodontic purposes were selected, thoroughly cleaned, and stored in physiological saline solution at room temperature for less than 3 months before use. A standard class V cavity (3 mm mesiodistal width, 3 mm occlusogingival height, and 1.5 mm axial depth) was prepared at the cemento-enamel junction (CEJ) on the facial surface of each tooth with a 0.5 mm wide 45° beveled enamel margin and a 90° cervical margin; the gingival margin was placed 1.0 mm below the CEJ. The preparation was performed with a straight fissure diamond bur (MANI Ltd., Utsunomiya, Japan) in a water-cooled high-speed handpiece by the one operator. The bur was replaced after every five preparations.

The specimens were randomly divided into five groups ($n = 14$) and restored with different flowable composite resins: groups I and II with EMBRACE WetBond (Pulpdent Corporation) with and without acid etching and bonding agent, respectively; group III flowable compomer (Dyract Flow, Dentsply, DeTrey, GmbH, Konstanz, Germany), and groups IV and V with microhybrid (Tetric Flow, Ivoclar Vivadent AG, Schaan, Liechtenstein) and nanofilled (Premise Flowable, Kerr Corporation, Orange, CA, USA) flowable composites, respectively.

For all groups except group II, the cavities were rinsed with water, etched with 37.5% phosphoric acid etching gel (Kerr Gel Etchant, Kerr Corporation) for 15 seconds, and rinsed with a water jet for 20 seconds; groups III, IV, and V were gently air dried to leave the surfaces wet. In group I surfaces were rinsed and excess water was removed with a cotton pellet. There was no pooling of water on the cavity, so that slightly moist surfaces were appearing shiny or glossy. The ethanol-based adhesive system (OptiBond Solo Plus, Kerr Corporation) was applied to the

cavities for 15 seconds; after adhesive application and solvent evaporation with gentle air spraying for 3 seconds, it was cured with a light-emitting diode unit (Kerr Corporation, Middleton, WI, USA) for 20 seconds according to the manufacturer's instruction. Group II was prepared without acid etching and bonding agents, rinsed like group I.

Flowable materials were placed in a single increment of shade A2 according to the manufacturers' instructions and the light curing unit was placed to the buccal surfaces at a close range (0-1 mm) and activated at 1000 mW/cm² for 20 seconds. The restorations were finished using water-cooled microfine diamond finishing burs (D+Z, Diamant GmbH, Lemgo, Germany) for contouring and removal of excess restorative material, and polished with aluminum oxide polisher (HiLuster Polishing System, KerrHawe, Bioggio, Switzerland) immediately after filling.

The teeth were stored in distilled water at 37°C for 1 month, thermocycled for 1500 cycles from 5° to 55°C with a 30-second dwell time and a transfer time of 3 seconds. The root apices of specimens were sealed with sticky wax; all external surfaces were covered with two layers of nail varnish except for 1.0 mm around the restorations and then immersed in a 0.5% basic fuchsin dye solution for 24 hours. The specimens were rinsed in running water and then dried. The teeth were sectioned faciolingually with a low speed diamond saw (D+Z, Diamant GmbH) under water spray.

The dye penetration depth along the cavity wall (including both occlusal and gingival margins) was measured with a stereomicroscope (Nikon Eclips E600, Tokyo, Japan) at 20× magnification. Two independent precalibrated investigators blindly scored dye penetration (microleakage) along the tooth-restoration interface and consensus was forced when disagreements

occurred. The microleakage score was recorded separately for both occlusal and cervical margins on a nonparametric ordinal scale from 0 to 3 as 0 = no microleakage; 1 = dye penetration less than ½ of axial wall; 2 = dye penetration more than ½ of axial wall; 3 = dye penetration spreading along the axial wall.^[10,15] Data were analyzed using Kruskal-Wallis analysis of variance and Mann-Whitney U-test for comparing the restorative materials; also occlusal and cervical margins were compared with each other with Wilcoxon signed rank test at a 0.05 significant level.

RESULTS

The frequency, mean, and standard deviations of the microleakage scores obtained from the experimental groups for the occlusal and cervical margins are presented in Table 1. Microleakage was observed in any restorations at the occlusal and cervical margins. Kruskal-Wallis analysis of variance revealed significant microleakage differences among the five groups at occlusal margins ($P = 0.001$), but not at cervical margins ($P > 0.05$).

When analyzing the effect of acid etching and bonding agent on EMBRACE WetBond, microleakage at the occlusal margins was significantly less than that without ($P = 0.002$), but not at cervical margins. Also cavities restored with EMBRACE WetBond without acid etching and bonding agent showed significantly greater microleakage scores than other groups at the occlusal margin ($P < 0.037$), but there was no significant difference at the cervical margin ($P > 0.05$).

When comparing each group individually at the occlusal margin, EMBRACE WetBond with acid etching and bonding agent had significantly greater microleakage than Premise Flowable, but there was no difference with Tetric Flow and Dyract Flow, while there was no significant difference between

Table 1: Frequency, mean ± SD of microleakage scores, and P value of the Wilcoxon signed rank test of the five flowable materials used on occlusal and gingival margins (n = 14)

Groups	Occlusal margins					Cervical margins					P value*
	0	1	2	3	Mean ± SD	0	1	2	3	Mean ± SD	
EMBRACE WetBond with AE [†] and BA [‡]	8	4	2	-	0.64 ± 0.63	8	2	3	1	0.64 ± 0.93	1.000
EMBRACE WetBond without AE and BA	1	5	4	4	1.79 ± 0.98	6	3	3	2	0.64 ± 0.75	0.001
Premise Flowable	12	1	1	-	0.21 ± 0.58	7	5	2	-	0.79 ± 1.05	0.023
Tetric Flow	10	3	1	-	0.36 ± 0.63	8	4	1	1	1.07 ± 1.07	0.004
Dyract Flow	7	3	2	2	0.93 ± 1.14	5	5	2	2	1.07 ± 1.14	0.157

*Wilcoxon signed rank test; [†]acid etching; [‡]bonding agent.

Premise Flowable and Tetric Flow. Also Dyract Flow had significantly greater microleakage than Premise Flowable, but the difference between Dyract Flow and Tetric Flow was not significant. At the cervical margin, there was no statistically significant microleakage differences between the five groups ($P > 0.05$).

A Wilcoxon signed rank test showed significantly less microleakage at the occlusal margins compared to the cervical margins in EMBRACE WetBond without acid etching and bonding agent ($P = 0.001$), Tetric Flow ($P = 0.004$) and Premise Flowable ($P = 0.023$) groups, but not in EMBRACE WetBond with acid etching and bonding agent and Dyract Flow groups ($P > 0.05$).

DISCUSSION

The results of this study showed that none of the tested flowable materials completely eliminated microleakage; nonetheless it is still a major drawback of flowable materials due to higher polymerization shrinkage and the coefficient of thermal expansion.^[9,10] Also, this study showed that with the exception of EMBRACE WetBond without acid etching and bonding agent, the remainder of the flowable materials under investigation exhibited satisfactory adaptation to enamel margin.

In the present study, EMBRACE WetBond with acid etching and bonding agent exhibited significantly less microleakage at the occlusal margins than those without. However, this effect was not found at the occlusal margins. Moreover, the results showed significantly greater microleakage at the occlusal margins compared to the cervical margins in EMBRACE WetBond without acid etching and bonding agent. According to the manufacturer's claim, EMBRACE WetBond evaluated in this study is self-etching to dentin; however, etching enamel surfaces is indicated, but bonding agents and etching dentin are not required, although they can be used, if desired. EMBRACE WetBond is 49% filled by weight with submicron and micron size particles.^[16]

Also EMBRACE WetBond without acid etching and bonding agent showed significantly the highest microleakage scores than other groups at occlusal margin. Nevertheless, based on the findings of this study, application of acid etching and bonding agent with EMBRACE WetBond is recommended for better adaptation at enamel margin. Phosphoric acid is capable to etch the enamel and remove the smear

layer, led to a deeper penetration of resin monomers and the formation of longer tags; therefore it improves the stability of adhesives and then provides a durable marginal seal.^[20,21] In the present study the bonding system that was used (OptiBond Solo Plus, Kerr) is a bonding agent for virtually every clinical application. It is ethanol-based, 15% filled with 0.4 μm filler, and actually reinforces dentine tubules at much greater depths than unfilled or nanofilled systems. This means a better long-term stability and outstanding bond strengths with direct or indirect applications.

Asefzadeh and colleagues showed that shear bond strength of EMBRACE WetBond without application of acid etching and bonding agent was significantly lower than Tetric Flow composite combined with Excite bond. They concluded that application dentin bonding agents with this flowable composite resin caused the best strength.^[22] According to the manufacturers, Tetric Flow is a fine-particle hybrid composite and given its low viscosity permits optimum wetting of the tooth. The total content of inorganic fillers is 64.6% wt, or 39.7% vol, and is indicated for class V restorations. The particle size is between 0.04 and 3.0 μm , and the mean particle size is 0.7 μm .^[23]

Among the experimental groups the Premise Flowable exhibited the best marginal adaptation to enamel. This result should be attributed to the properties of the restorative material, since the other experimental conditions, such as the C-factor of the experimental cavities, the application technique, and the bonding characteristics of the cavity walls, were identical in all restorations except EMBRACE WetBond without acid etching and bonding agent. According to the manufacturer, Premise Flowable is a medium viscosity, nanofilled, light-cured composite suitable for numerous direct applications. It has a high filler loading (72.5 wt%, 54.6% vol), 2.95% shrinkage, and 20% less shrinkage than leading brands, also minimizing stress, sensitivity, and microleakage. The prepolymerized filler and nanofiller are combined to deliver optimal mechanical strength, durability, and reduced polymerization shrinkage,^[24] which might explain the reason of their dye penetration.

On the whole, Premise Flowable exhibited the lowest microleakage, while EMBRACE WetBond combined without bonding agent presented the highest, and EMBRACE WetBond combined with bonding agent, Tetric Flow and Dyract Flow were intermediate at the occlusal margin. Flowable compomers are now

considered a distinct class of dental restorative, and are a group of esthetic materials chemically similar to the well-established composite resins.^[25] They were intended to combine the benefits of traditional composite resins and those of glass ionomer cements such as adhesion and fluoride releasing.^[26] Dyract Flow is an ideal material for small cavities such as class V, and is used with a self-priming adhesive to bond enamel and dentin.^[27] Awliya and El-Sahn in an *in vitro* study concluded that almost no gap formation at the interface was observed in cavities restored with Grandio Flow composite resin. Grandio Flow is a nanofilled flowable composite resin which has high filler loading (65.6%). This might explain the low volumetric shrinkage of Grandio Flow and subsequently its resistance to gap formation.^[28]

Microleakage is more critical in class V cavities as due to the majority of cervical margins these lesions are located in both dentine and/or cementum, which may lead to a weaker marginal seal than that at the enamel surface. However, it is essential to obtain a reliable dentin bond to the restorative material.^[1,29] The adhesion between composite resins and dentin is not as strong as with enamel; therefore the material can be dislodged toward occlusal during polymerization contraction, causing a bad adaptation of the restoration at the cervical margins.^[30] In the present study, when comparing the occlusal and the cervical margins of the restorations, totally no statistically significant differences of microleakage were observed between the occlusal and gingival margins. Similarly, Estafan *et al.*^[19] found no difference in occlusal or cervical microleakage of cavities restored with flowable composite resins. While, individually, higher microleakage scores were detected in the cervical margin when compared to the occlusal margin in groups I and II, no difference in microleakage scores was observed in Dyract Flow and EMBRACE WetBond with acid etching and bonding agent, which can be related to the composition of these two tissues and these flowable materials. This finding is in agreement with some studies: Jang *et al.*,^[12] Chimello *et al.*,^[15] and Monticelli *et al.*^[31] reported greater microleakage scores at the occlusal margins than cervical margins.

CONCLUSION

Within the limitations of this *in vitro* study, it may be concluded that in class V cavities the application of acid etching and bonding agent with EMBRACE

WetBond provided better occlusal marginal sealing than those without. However, biomechanical properties improvement, *in vitro*, and long-term clinical trials studies still are necessary.

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