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Original Article

Comparison of self-adhering flowable composite microleakage with several types of bonding agent in class V cavity restoration

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ABSTRACT

Background: The aim of the present study was to compare the marginal seal of self-adhering flowable composite resin with three universal bonding systems using the self-etch technique in Cl V cavities at enamel and dentin margins.
Materials and Methods: In this *in vitro* study, Cl V cavities were prepared on the buccal surfaces of forty premolars, with the occlusal margin of each cavity on enamel and gingival margin on dentin. The teeth were divided into four groups (n = 10) in terms of the adhesive used; Group 1: Vertise Flow (VF) self-adhering composite resin, Group 2: Clearfil S3 Bond Universal (CS3BU), Group 3: G-Premio Bond (GPB), Group 4: Single Bond Universal (SBU). In Groups 2, 3, and 4, Z350 flowable composite resin was used to restore the cavities. After thermocycling, the samples were immersed in 10% methylene blue for 24 h and evaluated under a stereomicroscope after buccolingual sectioning; microleakage at enamel and dentin margins was recorded. Kruskal–Wallis and Mann–Whitney tests were used for statistical analyses. Statistical significance was set at $P < 0.5$.
Results: Vertis Flow self-adhering composite resin exhibited significantly higher microleakage at enamel and dentin margins compared to SBU and CS3BU; however, it had significantly less microleakage at enamel margin compared to GPB ($P < 0.05$). At the enamel and dentin margins, the minimum microleakage values were recorded at SBU and CS3BU margins, respectively. GPB exhibited the highest microleakage values among the groups evaluated and in all the groups, microleakage at dentin and enamel margins was significantly different ($P < 0.05$) except for SBU group.
Conclusion: The marginal sealing ability of self-adhering flowable composite resin at enamel and dentin margins was poor compared to the majority of bonding agents evaluated.

Key Words: Adhesive, composite resin, dental leakage

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INTRODUCTION

Simplification of bonding steps in composite resin restorations has been one of the most important aims of the development of dental adhesives. In addition to the simplification and shortening of the necessary time, decreasing and confinement of procedural errors has always been an aim for researchers.[1] To this end, in recent years, single-bottle universal adhesives have been introduced,[2] which can be applied in different self-etch, total etch and enamel selective etch modes.[3] In addition, they can bond to different restorative materials, including metals and ceramics.[4,5]

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Flowable composite resins were initially developed for use in Cl V cavities.[6] However, nowadays they are used in different clinical procedures, including the restoration of small carious lesions, for sealing pits and fissures, and as liners for composite resin restorations.[7] Flowable composite resins are easily placed in small cavities and they are expected to exhibit better adaptation with the cavity walls compared to composite resins with higher viscosity[8,9] Due to lower filler content, these composite resins have lower modulus of elasticity and higher polymerization shrinkage compare to conventional composite resin.[10]

One of the recent advances in dentistry is the introduction of self-adhering flowable composite resins which are a product of combining an all-in-one bonding system and flowable composite resin.[11] By the incorporation of glycero-phosphate dimethacrylate functional monomer into the chemical composition of composite resins, the steps of direct restorative procedures are simplified.[12] Based on manufacturer's claim, this monomer exhibits acidic properties; it etches the tooth structure, bonds to the calcium of tooth structure, and has two functional methacrylate groups, which can copolymerize with other methacrylate monomers.[13] Therefore, use of these composite resins results in shortening of the time needed to apply them and the procedural errors and technique sensitivity decrease. Based on previous studies, these composite resins have the highest elastic modulus, hardness,[14] and degree of conversion[15] compared to other conventional flowable composite resins. In addition, these composite resins exhibited higher hygroscopic dimensional expansion[16] and more water sorption,[17] compared to other flowable composite resins, 150 days after immersion in water.

Some studies have reported that selective etching with phosphoric acid and use of a bonding agent is effective for bonding ability of these composites to tooth structure.[18-20] Different studies have compared the bonding ability of these composite resins to tooth structure with that of other bonding systems, reporting different results.[11,13]

Although clinical studies yield more valid results and use of *in vitro* findings has its specific limitations, laboratory tests are still useful for collecting initial data.[21] One of these laboratory tests is microleakage test which is used for the evaluation of the sealing ability of materials. Poor seal and open margins is the main factor for marginal discoloration, recurrent caries and pulpal injury.[22] Given the importance of the marginal seal of composite resin restorations, the aim of the preset study was to evaluate microleakage of flowable composite resin compared with universal bonding systems using the self-etch technique. Based on null hypothesis, there was no significant difference in the marginal sealing ability between self-adhering flowable composite resins and universal bonding systems.

MATERIALS AND METHODS

The protocol of this *in vitro* present study was approved by the Ethics Committee of Zanjan University of Medical Sciences. Forty extracted teeth were selected and immersed in 0.5% chloramine solution at 4°C for almost 1 month before the study to prevent bacterial growth. All teeth were sound. The teeth with caries, restorations, trauma, enamel defects, and any congenital anomalies were excluded from the study.

Cl V cavities, measuring 2 mm in mesiodistal width, 2 mm occlusoginivally, and 1 mm in depth, were prepared on the buccal surface of each tooth with the use of a carbide fissure bur (010 SS White, Switzerland) under air and water spray using a high-speed handpiece. A periodontal probe was used to assess the accuracy of cavity dimensions. The cavities were prepared in a manner to place their center at the cemento-enamel junction; therefore, the occlusal margin was placed on the enamel and the gingival margin on the dentin or cementum. Finally, 0.5-mm bevel was placed on the enamel margin. A new bur was used for every 4 teeth.

The teeth were randomly assigned to four groups (*n* = 10) and conditioned with different universal bonding agents using the self-tech technique according to manufacturer's instructions and then restored with composite resin [Table 1]. For the purpose of matching, all the procedural steps were carried out by one operator.

- Group 1: Vertise Flow (VF) (Kerr, Orange, CA, USA)
- Group 2: Clearfil S3 Universal (Kuraray Noritake, Tokyo, Japan)
- Group 3: G-Premio Bond (GC, Tokyo, Japan)
- Group 4: Single Bond Universal (3M ESPE, St. Paul, MN, USA).

The samples in Groups 2–4 were restored with flowable Z350 Filtek composite resin (3M ESPE,

Table 1: Materials used in the study

Product name	Manufacture	Composition	Instruction for use
Vertise flow	Kerr, Orange, CA, USA	GPDM adhesive monomer, Prepolymerized filler containing barium glass filler, nano-sized colloidal silica, nano-sized ytterbium fluoride pH=1.9	Brush a thin layer (<0.5 mm) of vertise flow for 15-20 s, Light cure for 20 s. Build additional layers (2 mm or less) then light cure for 20 s
Clearfil S3 Bond Plus	Kuraray Noritake Dental Inc., Tokyo, Japan	10-MDP, 2-HEMA, Bis-GMA, hydrophilic and hydrophobic aliphatic dimethacrylates, sodium fluoride, colloidal silica, ethanol, water, photoinitiators pH=2.7	1. Apply bond and leave undisturbed for 10 s 2. Dry by blowing mild air for more than 5 s until the bond does not move 3. Light cure for 10 s
G-Premio Bond	GC Corp., Tokyo, Japan	10-MDP, 4-META, 10-methacryloyloxydecyl dihydrogen thiophosphate, methacrylic acid ester, acetone, water, photoinitiators pH=1.5	1. Apply adhesive can be left untouched for up to 10 s 2. Dry by blowing air for 5 s 3. Light cure for 10 s
Single bond Universal	3M ESPE, St. Paul, MN, USA	10-MDP, 2-HEMA, silane, dimethacrylate resins, methacrylate modified polyalkenoic acid copolymer, filler, ethanol, water, photoinitiators pH=2.7	1. Apply the adhesive to the entire preparation and agitate for 20 s 2. Gently air blow over the liquid for 5 s until the latter no longer moves 3. Light cure for 10 s
Filtek Z350 Flowable	3M ESPE, St. Paul, MN, USA	Bis-GMA, TEGDMA, procrylat resins, ytterbium trifluoride filler, silica, and zirconia nano filler	Apply composite in maximum 2 mm thickness then light cure for 20 s

GPDM: Glycero-phosphate dimethacrylate, HEMA: 2-hydroxyethyl methacrylate, 4-META: 4-methacryloyloxyethy trimellitate anhydride, TEGDMA: Triethylene glycol dimethacrylate,10- MDP: 10-methacryloyloxy decyl dihydrogen phosphate, Bis GMA: Bis phenol glycidyl dimethacrylate

St. Paul, MN, USA) after application of bonding agents. Light-curing was carried out with a halogen light-curing unit (Starlight Pro; Mectron s. p. a. Carasco, Italy, 1400 mw/cm^2, 440–465 nm) in all the study groups. After restorative procedures, the restorations were polished and the samples were stored in distilled water at 27°C for 24 h.

Subsequently, the samples were subjected to a 500-cycle thermocycling procedure at 5/55°C with a dwell time of 30 s and a transfer time of 5 s. To carry out microleakage test, the apex of each tooth was sealed with sticky wax and all the tooth surfaces were covered with two layers of nail polish up to 1 mm from the cavity margins. Then all the samples were immersed in 10% methylene blue for 24 h. After retrieving the samples from the solution and rinsing them, the teeth were mounted in acrylic resin for better handling of the samples during sectioning. The mounted teeth were sectioned at the mid-sagittal area using a Mecatome machine (Pressi, France) under water cooling and evaluated under a stereomicroscope (Kyowa, Japan) at 50X at gingival and occlusal margins. For the purpose of blinding, evaluation of microleakage was carried out by a researcher who was unaware of the study groups. Microleakage at occlusal (enamel) and gingival (dentin) margins was classified as follows in terms of penetration of dye at restoration margins [Figure 1]:

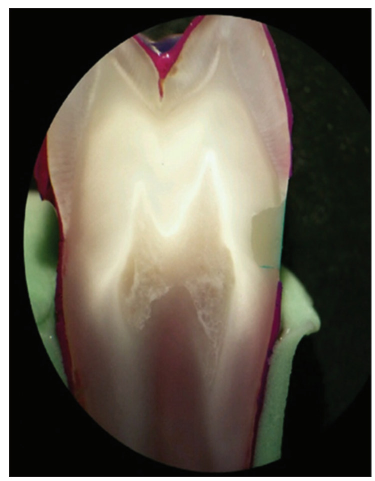

Figure 1: Dye penetration: Score 0 in enamel margin and score 2 in dentinal margin.

- Score 0: No dye penetration
- Score 1: Dye penetration up to half of the cavity depth or less than that
- Score 2: Dye penetration up to more than half of the cavity depth without affecting the axial wall
- Score 3: Dye penetration to all the cavity walls with involvement of the axial wall.

Only the tooth side with maximum dye penetration at enamel or dentin margin was analyzed statistically. Nonparametric Kruskal–Wallis test was used to compare the 4 study groups at enamel and dentin margins. Mann–Whitney test was used to compare enamel and dentin margins in each group. Statistical significance was set at $P < 0.5$.

RESULTS

Evaluation of enamel and dentin margins under a stereomicroscope revealed various degrees of microleakage [Table 2]. Statistical analyses showed significant differences in microleakage at enamel margins between the study groups ($P < 0.05$). The most frequent score at the enamel margin was score 1 in all the groups except Single Bond Universal group where score 1 (50%) was as same as score 0 (50%) [Figure 2].

VF self-adhering composite resin exhibited significantly more microleakage at the enamel margin compared to Single Bond Universal and Clearfil S3 Bond Universal bonding systems; while it demonstrated significantly less microleakage at enamel margin compared to the G-Premio Bond group ($P < 0.05$). Based on the results at the enamel margin the decreasing scale of microleakage between the bonding systems was as follows: G-Premio Bond > Clearfil S3 Bond Universal > Single Bond Universal ($P < 0.05$).

There were significant differences in microleakage at the dentin margin between the study groups, except for VF and G-Premio Bond groups ($P < 0.05$). At the dentin margin score0 and score1 were the most common observation in all the groups except G-Premio Bond group where score0 was not observed at all [Figure 3].

Table 2: Frequency distribution of microleakage scores in study groups, based on enamel and dentinal margins

Group	Microleakage score, *n* (%)				Significance (P<0.05)
	0	1	2	3	
Enamel margin					
Vertise flow	1 (10)	7 (70)	2 (20)	0 (0)	A*a**
Clearfil S3 bond universal	3 (30)	6 (60)	1 (10)	0 (0)	Ba
G-premio bond	1 (10)	4 (40)	2 (20)	3 (30)	Ca
Single bond universal	5 (50)	5 (50)	0 (0)	0 (0)	Da
Dentinal margin					
Vertise flow	3 (30)	6 (60)	1 (10)	0 (0)	Ab
Clearfil S3 bond universal	8 (80)	2 (20)	0 (0)	0 (0)	Bb
G-premio bond	0 (0)	7 (70)	1 (10)	2 (20)	Ab
Single bond universal	5 (50)	5 (50)	0 (0)	0 (0)	Ca

*Different upper cases means significant differences of microleakage score between four study groups, **Different lower cases means significant differences of microleakage score between enamel and dentinal margins in each study group

VF self-adhering composite resin exhibited significantly more microleakage at the dentin margin compared to Single Bond Universal and Clearfil S3 Bond Universal bonding systems. Among the study adhesives, the lowest microleakage score at the dentin margin was recorded in the Clearfil S3 Bond Universal group and the highest microleakage was observed in the G-Premio Bond group.

In each study group, microleakage was significantly different between the enamel and dentin margins except for the Single Bond Universal group ($P < 0.05$).

DISCUSSION

Marginal seal is a key factor for the success of a restoration; it ensures the longevity of the restoration. Marginal seal depends on several factors, including the polymerization shrinkage, bonding to tooth structure, the elastic modulus of composite resin, thermal expansion coefficient of composite resin and its water sorption.[23] Stresses resulting from polymerization of composite resin give rise to cracking of enamel

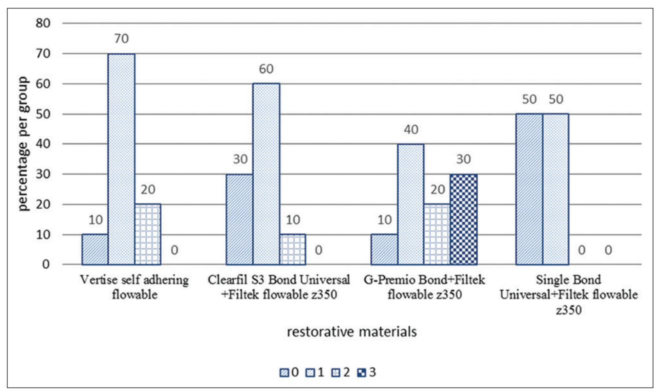

Figure 2: Comparison of microleakage percentage between study groups in enamel margin.

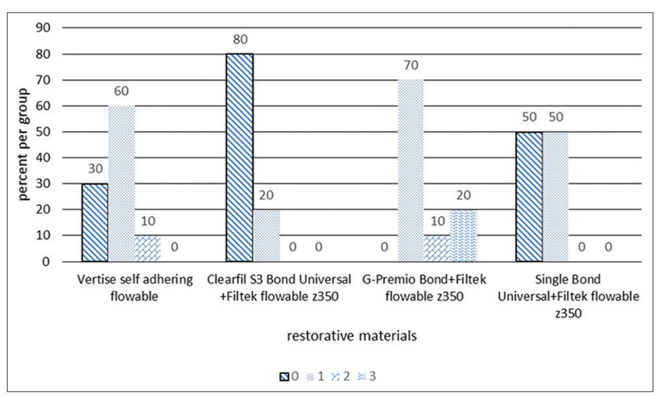

Figure 3: Comparison of microleakage percentage between study groups in dentinal margin.

prisms and marginal gaps; microleakage occurs due to the presence of these gaps around composite resin restorations.[24]

In the present study, microleakage evaluation was used to study bonding systems and flowable composite resin. Cl V cavities were prepared with a high C-factor due to the high ratio of bonded surfaces-to-unbonded free surfaces.[25] Thermocycling was applied to simulate thermal changes that occur in the oral cavity (500 cycles at 5/55°C) because thermal changes can affect microleakage. In addition, it has been shown that limited thermal cycles are adequate for the evaluation of microleakage,[26] and microleakage increases with an increase in the number of thermal cycles in Cl V cavities.[27]

Based on the results of the present study, there were significant differences in the marginal sealing ability between the study groups at enamel and dentin margins, refuting the null hypothesis of the study. This is consistent with the results reported by Vichi *et al*.,[11] who reported significant differences between the microleakage of all-in-one adhesive systems and self-adhering flowable composite resins in classic cavities; however, in their study, the marginal seal with self-adhering flowable composite resin was better than other bonding systems, which does not coincide with the results of the present study. In addition, another study showed that microleakage at dentin margins with the use of self-adhering flowable composite resin was more than that with the use of a 3-step etch-and-rise adhesive agent.[28]

In contrast to the results of the present study, a study by Bektas *et al*.[19] did not reveal any significant differences in microleakage between Vertise flowable composite resin and a self-etch all-in-one adhesive agent at enamel and dentin margins. In addition, another study did not show any significant differences in the enamel and dentin marginal seal between self-adhering flowable composite resin and different bonding systems.[13]

In the present study, it was concluded that microleakage at enamel and dentin margins with the use of VF composite resin was more than that with the use of two other universal bonding systems in self-etch mode, except for G-Premio Bond system. This might be attributed to the poor wetting ability of this composite resin. Proper wetting ability of an adhesive agent on a substrate results in an intimate reaction between the substrate and the adhesive agent.[29] Compared to other adhesive systems evaluated in the present study, VF has higher filler content and viscosity, no solvent and exhibits less wettability. These properties limit the ability of this material to penetrate into the exposed collagen network, despite the active use of the first layer of this material.[11,30] Scanning electron microscope images have shown that this composite resin has a relatively superficial reaction with the tooth structure and does not form a clear hybrid layer.[11] Due to such poor reaction between self-adhering flowable composite resins and tooth structures, several studies have reported that use of bonding agents increases the marginal seal of these composite resins at dentinal walls.[1,18,19]

In the present study, universal bonding systems with the use of self-etch technique were compared with self-adhering flowable composite resin. One-step bonding systems have advantages such as simplifications, shortening of procedural steps and a decrease in technique sensitivity. Therefore, it was considered logical to make comparisons between universal adhesive systems in self-etch mode and VF composite resin.

The results of the present study showed significant differences in microleakage between different bonding systems at enamel and dentin margins, consistent with the results of the previous studies,[11,13] which might be attributed to differences in the chemical composition of these bonding agents.

Solvents are one of the most important components of universal bonding systems. The bonding systems evaluated in the present study were different from each other in relation to their solvents. Clearfil S3 Bond Universal and Single Bond Universal contain water and ethanol; according to the results they exhibited less microleakage compared to G-Premio Bond, which contains acetone. This is consistent with the results of previous studies which have reported a higher bonding ability in all-in-one adhesives containing a higher amount of ethanol.[11,31] In addition, previous studies have shown that the acetone in G-Premio Bond might affect the formation of nano-layering through a change in the polarity of the solvent, with the subsequent hydrophobic effect of methacryloyloxydecyl dihydrogen phosphate (MDP) in the adhesive.[32]

On the other hand, one of the monomers in the G-Premio Bond adhesive, which does not exist in the two other bonding systems, is 4-methacryloyloxyethy trimellitate anhydride, which is hydrolyzed to 4-methacryloyloxyethy trimellitate after its contact with water.[33] This monomer greatly limits formation of nano-layering by 10-MDP-Ca salts.[33]

Contrary to G-Premio Bond, Clearfil S3 Bond Universal and Single Bond Universal bonding systems contain 2-hydroxyethyl methacrylate monomer, which increases the wettability of the adhesivePrevious studies have shown less water drops in the hybrid layer formed by adhesives containing this monomer.[34,35]

It has been reported that pH can affect the bonding of bonding systems to the surface of dentin, too. In self-etch bonding systems, a pH value of >2 slows removal of minerals from the dentin surface and results in adequate time for the residual hydroxyapatite crystals to protect and open collagen fibers.[36] The pH value in Clearfil S3 Bond Universal and Single Bond Universal is >2 and G-Premio Bond has a pH value of <2 [Table 1].

The amount of microleakage at enamel and dentin margins was significantly different in each study group except for the Single Bond Universal group. Since the microleakage of VF self-adhering flowable composite resin at enamel margin was more than that at the dentin margin, it appears etching the enamel surface before placing this composite resin is effective in decreasing microleakage.[1,28] However, use of phosphoric acid on the dentin surface before placing self-adhering flowable composite resin might have a deleterious effect on the sealing ability of this composite resin due to excessive demineralization of the dentin surface and collapse of the collagen network.[1,13]

In the present study, since only the microleakage of self-etch universal boning systems and self-adhering flowable composite resin was evaluated, it is suggested that further studies be undertaken to evaluate the bond strength of universal bonding systems using different techniques and self-adhering flowable composite resins.

CONCLUSION

Under the limitations of the present study, the results showed that the marginal sealing ability of VF composite resin of enamel and dentin margins is not superior to that of other bonding agents evaluated. Therefore, caution should be exercise with the use of this composite resin without surface preparation or with the use of bonding agents. In this context, further studies are necessary to evaluate the efficacy of self-adhering flowable composite resins in the clinic.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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