

BOND STRENGTH AND INTERFACIAL MORPHOLOGY EVALUATION OF SELF-ADHERING FLOWABLE COMPOSITES

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ABSTRACT

Objectives: To evaluate the micro-shear bond strength (μ SBS) and interfacial morphology to dentin of self-adhering flowable composites (SAFCs) in comparison to a combination of all-in-one adhesive and conventional flowable composite (CFC).

Materials and Methods: Forty prepared adult tooth dentin surfaces were randomly divided into 4 groups (n=10) according to adhesive and/or flowable composite material applied: group I: Dyad Flow (SAFC; Kerr, USA); group II: Fusio Liquid Dentin (SAFC; Pentron Clinical, USA); group III: Vertise Flow (SAFC; Kerr, USA); group IV: OptiBond All-In-One (Kerr) + Premise Flowable (CFC, Kerr, USA). Composite micro-specimens of each group were prepared on dentin surfaces according to manufacturer's instructions, then stored in distilled water (37 °C, 24 h.) before μ SBS testing. For interfacial morphology evaluation, mesial and distal class II slots were prepared in each of 16 teeth, then each group (n=4) were restored with its respective composite. Each specimen was sectioned mesio-distally and prepared for interface evaluation by SEM. μ SBS data were analyzed using one-way ANOVA, followed by Tukey test.

Results: Each of the Self-adhering flowable composites (group I, II, and III) recorded μ SBS value that was statistically comparable to that measured by a combination of all-in-one adhesive and conventional flowable composite (group IV). Also, there were no significant differences (p>0.05) in μ SBS among Self-adhering flowable composite materials. SEM images showed that all materials exhibited a continuous interface and appeared well-adapted to dentin.

Conclusions: All Self-adhering flowable composites tested achieved satisfactory μ SBS and marginal adaptation to dentin substrate.

KEYWORDS: Flowable composite; Self-adhering; All-In-One adhesive; Micro-shear bond strength; SEM.

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INTRODUCTION

A dramatic improvement in resin composite formulation and adhesive technology has occurred since the initial introduction of resin composite in 1960s. Numerous efforts have been focused on dentin and bonding systems in the last two decades to achieve a durable bonding mechanism.⁽¹⁾ High and stable bonding of resin composites to tooth structure substrates is critical for obtaining marginally sealed and durable restorations.⁽²⁾ Simplification has been a principal in the research advancement of dental adhesives not only to facilitate procedures, but also to reduce handling errors and technique sensitivity.^(3,4) These advancements and efforts has led to the introduction of all-in-one adhesive systems.^(1,5-12) These systems is established on self-etch mechanism which is relied on acidic resin monomer for simultaneous demineralization and resin infiltration of the substrate.^(2,13) The elimination of separate etching, rinsing, and drying steps in all-in-one systems is an advantageous from the clinical standpoint, since the possibility of cavity contamination is minimized,⁽¹⁴⁾ over wetting and over drying are lessened,⁽¹⁵⁾ and the risk of post-operative sensitivity is reduced.⁽¹³⁾ In addition, the bonding procedure is simplified and chair time is saved.⁽¹⁶⁾

Flowable resin composites were first introduced in the late 1996⁽¹⁷⁾ with two particular properties: low modulus of elasticity and increased flowability and wettability.⁽¹⁸⁾ Low modulus of elasticity help to relief polymerization shrinkage stresses and consequently preserve marginal integrity,⁽¹⁹⁻²¹⁾ while increased flowability and wetting results in an intimate contact with the floor and walls of the cavity leading to improved marginal adaptation.^(12,23) On the other hand, it is generally accepted that flowable resin composites has inferior mechanical properties in comparison to conventional composites due to their lower filler load.^(21, 24-26) Therefore, flowable composites have been recommended to be used as restorative material in low stress-bearing areas and in situations where access is difficult or deep

penetration is essential such as: small class III and class V restorations, small cavities where most of the occlusal forces resisted by remaining tooth structure, enamel defect repair, incisal edge repair, porcelain repair, crown margin or composite defect repair, and pit and fissure sealing; while it is suggested to be used only as cavity liner in restorations of cavities in high stress-bearing areas.^(18,25,27)

With passing of time and as a result of continuing efforts to simplify daily clinical treatment procedures and to decrease handling errors, a new category of flowable composites, the so-called self-adhering flowable resin composite was introduced that combines the properties of self-adhesion and flowability.⁽²⁸⁾ Restorations with these composites eliminate the need of etching and bonding steps that normally required for bonding a conventional flowable composites to enamel and dentin.⁽²⁾ Due to the rapid progress in the categories of self-etch adhesives and resin composites and since it has been reported that the performance of these new materials is product-dependent to a significant extent,⁽²⁹⁾ it becomes essential to expose the newly introduced materials to laboratory investigations that present data with a predictive value of clinical outcome.⁽³⁰⁾ Among laboratory tests, bond strength tests are widely used to provide a quantitative measurement of materials adhesion based on the concept that the stronger the bond, the better it will resist the polymerization shrinkage and functional stresses at interface.⁽⁶⁾ Marginal adaptation and sealing ability of adhesive materials are among properties of significant clinical relevance.⁽³⁰⁾ It was reported that insufficient sealing and marginal leakage cause bacterial invasion, leading to secondary caries and pulpal damage.⁽¹⁾

To the best of our knowledge, there is limited documentation, in the literature, regarding bond strength and marginal adaptation of new self-adhering flowable composites. The present study aimed to investigate the micro-shear bond strength and interfacial morphology to dentin of newly introduced self-adhering flowable composites in

comparison to a combination of all-in-one adhesive and conventional flowable composite. The tested null hypothesis was that similar bond strength and interfacial morphology to dentin are obtained by the new self-adhering flowable composites and by all-in-one adhesive used in combination with the conventional flowable composite.

MATERIALS AND METHODS

Three self-adhering flowable composites and one conventional flowable composite with its all-in-one adhesive were used in this study. The materials used as well as their manufacturers, types, compositions, and application procedures are listed in table 1. The shade of all composites used was A3.

A total of fifty six extracted, non- carious human molars were collected for this study. Teeth were cleaned and stored in 0.5% chloramine solution at 4°C for not more than two months until used in the study. Forty teeth were used for μ SBS test. The remaining sixteen molars reserved for SEM evaluation of interfacial morphology.

Micro-shear bond strength test

The forty molars intended for μ SBS test were embedded in self-curing acrylic resin (Acroston, Egypt) up to 1 mm below the cemento-enamel junction with their long axis perpendicular to the base of resin cylinder. Then, occlusal segment of the crown of each embedded tooth was removed

TABLE (1) Chemical compositions and application modes of the materials used in the study

Material	Type*	Composition*	Application*
Dyad Flow (Kerr, Orange, CA, USA)	Self-adhering flowable composite	Matrix: GPDM, HEMA, methacrylate co-monomers Filler: PPF, barium glass (1 μ m), nano silica filler (10-40 nm), nano ytterbium fluoride (40 nm). (70% wt)	Dispense first layer < 0.5 mm thick on a forcefully dried surface; brush with moderate pressure for 15-20 sec; light cure for 20 sec; apply a second layer 1.5 mm thick; light cure for 20 sec.
Fusio Liquid Dentin (Penetron, Wallingford, CT, USA)	Self-adhering flowable composite	Matrix: 4-META, HEMA, UDMA, TEGDMA Filler: Nano-sized amorphous silica, barium glass (65% wt)	Dispense first layer 1 mm thick on a briefly dried surface; agitate for 15-20 sec; light cure for 20 sec; apply a second layer 1 mm thick; light cure for 20 sec.
Vertise Flow (Kerr, Orange, CA, USA)	Self-adhering flowable composite	Matrix: GPDM, HEMA, methacrylate co-monomers Filler: PPF, barium glass (1 μ m), nano silica filler (20 nm), nano ytterbium fluoride (40 nm). (70% wt)	Dispense first layer < 0.5 mm thick on a forcefully dried surface; brush with moderate pressure for 15-20 sec; light cure for 20 sec; apply a second layer 1.5 mm thick; light cure for 20 sec.
Permise Flowable (Kerr, Orange, CA, USA)	Conventional flowable composite	Matrix: Ethoxylated bis-DMA, TEGDMA, organophosphate dispersant Filler: PPF, barium glass (0.4 μ m), nano silica filler (20 nm). (72.5% wt)	Apply 2 mm thick layer; light cure for 20 sec.
OptiBond All-In-One (Kerr, Orange, CA, USA)	One step self-etch adhesive	GPDM, HEMA mono and di-functional methacrylate monomers, nanofillers including sodium hexafluorosilicate, water, acetone, ethyl alcohol, photoinitiators	Apply first coat and brush with scrubbing motion for 20 sec; apply a second coat and brush with scrubbing motion for 20 sec; air dry gently for 5 sec; light cure for 10 sec.

GPDM: glycerol phosphate dimethacrylate; HEMA: hydroxyethyl methacrylate; PPF: prepolymerized filler; 4-META: 4-methacryloxyethyl trimellitic acid; UDMA: urethane dimethacrylate; bis-DMA: bisphenol-A-dimethacrylate; TEGDMA: triethylene glycol dimethacrylate.

* Information provided by the manufacturers.

using a water-cooled diamond saw (Isomet 1000, Buehler Ltd, Lake Bluff, IL, USA) to expose a flat mid coronal dentin. To obtain standardized smear layers, dentin surfaces were then polished on wet 600-grit silicon carbide paper for 60 sec.

The prepared teeth were randomly divided into four groups (n= 10) according to the adhesive and/or flowable composite material applied: group I, Dyad Flow; group II: Fusio Liquid Dentin; group III, Vertise Flow; group IV, OptiBond All-In-One adhesive and Permise Flowable.

The dentin surface was washed thoroughly with water spray and air dried without desiccation according to the manufacturer's instructions. Polyethylene tubes (Tygon Medical Tubing Formulations, Akron, OH, USA) with 1.2 mm internal diameter and 2 mm height were used to hold and build-up composite cylinders on dentin surfaces. The tested flowable composite materials were applied directly on the dentin surfaces except for group IV, where OptiBond All-In-One adhesive was applied first before composite application. All materials applied following the manufacturer's instructions (Table 1) and photo cured using LED Blue phase C8 curing unit (Ivoclar Vivadent AG, Schaan, Liechtenstein, Germany) with 850 Mw/cm output. The output intensity of the curing unit was verified after every ten exposures. All specimens were prepared by the same operator. After light polymerization, the tubes was carefully removed from the composite cylinders with a sharp blade, then each dentin-composite interface was checked with a magnifying lens (Q Optics, DentaTown L.L.C., Phoenix, USA) at X5 magnification and defective samples were excluded. The specimens were stored in distilled water for 24 hours at 37 °C before μ SBS testing.

Each acrylic embedded tooth with its own bonded composite micro-cylinders was secured with tightening screws to the lower fixed compartment of a testing machine (Model LRX-plus; Lloyd

Instruments Ltd., Fareham, UK) with a load cell of 5 KN. A loop prepared from an orthodontic wire (0.014 inch diameter) was wrapped around the bonded composite micro-cylinder as close as possible to its base and aligned with the loading axis of the upper movable compartment of the testing machine. A shearing load with tensile mode of force was applied at a crosshead speed of 0.5 mm/min until failure occurred. The load at failure (N) was divided by bonding area (mm²) to calculate the bond strength in MPa. Failure modes were evaluated under a light stereomicroscope (Olympus SZ 6045 TR Zoom, Olympus Optical Co, Osaka, Japan) at X20 magnification by a single operator and classified as adhesive (if it occurred at dentin/adhesive or material interface), cohesive (if it occurred in material or dentin) or mixed (if adhesive and cohesive fractures occurred concurrently).

Interfacial morphology

Sixteen molars were used to evaluate the interface between the resin composites and dentin by SEM. The occlusal surfaces were ground flat at the level of marginal ridges under water coolant to obtain a flat surface that was 4 mm above the cement-enamel junction and perpendicular to the long axis of the tooth. Class II slots were prepared on the mesial and distal surfaces using carbide bur # C21 (Jota, Swiss dentistry) mounted in a high-speed water cooled handpiece. The cavity preparation dimensions were: 3 mm width, 4 mm length (at the cement-enamel junction) and 1.5 mm depth. The prepared teeth were randomly divided into four groups (n=4) and the slots of each group were restored with its respective flowable composite, according to the manufacturer's instruction, as done in μ SBS test. Then the restored molars were sectioned mesio-distally into two halves using a diamond disk with copious water spray obtaining 8 interface sections for each group. After sectioning procedures, the samples were immersed in 6 mol/L HCL for 30 seconds; to dissolve the mineral component of dentin; rinsed, then they were

immersed in 1% NaOCL for 10 minutes to remove any non-infiltrated demineralized dentin matrix (collagen fibers and other organic parts of dentin) or unpolymerized resin. The specimens sections were washed with a copious amount of water and left to dry for 24 hour. This methodology was followed according to Nakabayashi and Takarada.⁽³¹⁾ After that, each section was gold sputtered and examined under SEM (JEOL, JSM T330, Japan). Micrographs were taken on specimens sections showing the restoration-tooth interface.

Statistical analyses

Data analysis of micro-shear bond strength was performed in several steps. Initially, descriptive statistics were done for each group results. As data passed normality test so parametric one way ANOVA followed by pair-wise Tukey's post-hoc tests were performed to detect significance among groups. Chi square test was done for comparison of different failure modes. Statistical analysis was performed using Aasistat 7.6 statistics software for Windows. P values ≤ 0.05 are considered to be statistically significant in all tests.

RESULTS

Micro-Shear bond strength

Means and standard deviations of micro-shear bond strength values are given in table 2 and displayed in figure 1. It was found that group III recorded the highest μ SBS mean value (19.6 ± 4.21 MPa) followed by group I (16.08 ± 2.33 MPa), then group IV (15.71 ± 3.36 MPa), whereas group II recorded the lowest μ SBS mean value (14.58 ± 4.621 MPa). The differences either between each of the self-adhering composites (group I, II, and III) and group IV, or among self-adhering composites were statistically non-significant ($p > 0.05$) as revealed by one way ANOVA test followed by pair-wise Tukey's post-hoc test.

TABLE (2) Descriptive statistics of the micro-shear bond strength to dentin

Groups	Materials	Mean (MPa)	Standard deviation	ANOVA (P value)
I	Dyad Flow	16.08 ^A	2.33	0.1142 (NS)
II	Fusio Liquid Dentin	14.58 ^A	4.62	
III	Vertise Flow	19.60 ^A	4.21	
IV	OptiBond All-In-one + Permise Flowable	15.71 ^A	3.36	

Same superscript letters label statistically not significant differences ($P > 0.05$). NS: not significant

Mode of failures

The frequent distribution (%) of failure modes are presented in table 3 and showed in figure 2. It was shown that the predominant failure pattern for all groups was the adhesive failure. However, the material with the highest μ SBS mean value (group III) exhibited the higher percentages of mixed and cohesive failure modes and the material with the lowest μ SBS mean value (group II) recorded the highest percentage of adhesive failure mode. There were no statistically significant differences among failure modes of all groups as indicated by Chi square test ($p > 0.05$).

Interfacial morphology

Scanning electron micrographs showed that all the materials exhibited a continuous interface and appeared well-adapted to the dentin substrate (Fig. 1). However a deeper resin infiltration was observed in Dyad Flow (Fig. 1a) and Vertise Flow (Fig. 1c). A clear, well-defined resin-impregnated layer of dentin was seen in OptiBond All-In-One adhesive image (Fig. 1d), with a minute gaps at the resin-composite interface were also visible. On the other hand, minimal short resin tags were observed in Fusio Liquid Dentin image (Fig. 1b), but the junction between this material and dentin appeared tight. A distinct thin hybrid layer was observed in all images of the tested specimens except for Fusio Liquid Dentin (Fig. 1b), where no definite hybrid layer can be seen.

TABLE (3) Frequent distribution (%) of failure modes for all materials tested

Groups	Materials	Failure modes			Chi square (P value)
		Adhesive	Cohesive	Mixed	
I	Dyad Flow	60	0	40	0.1596 (NS)
II	Fusio Liquid Dentin	80	0	20	
III	Vertise Flow	50	10	40	
IV	OptiBond All-In-One + Permise Flowable	70	0	30	

NS: not significant

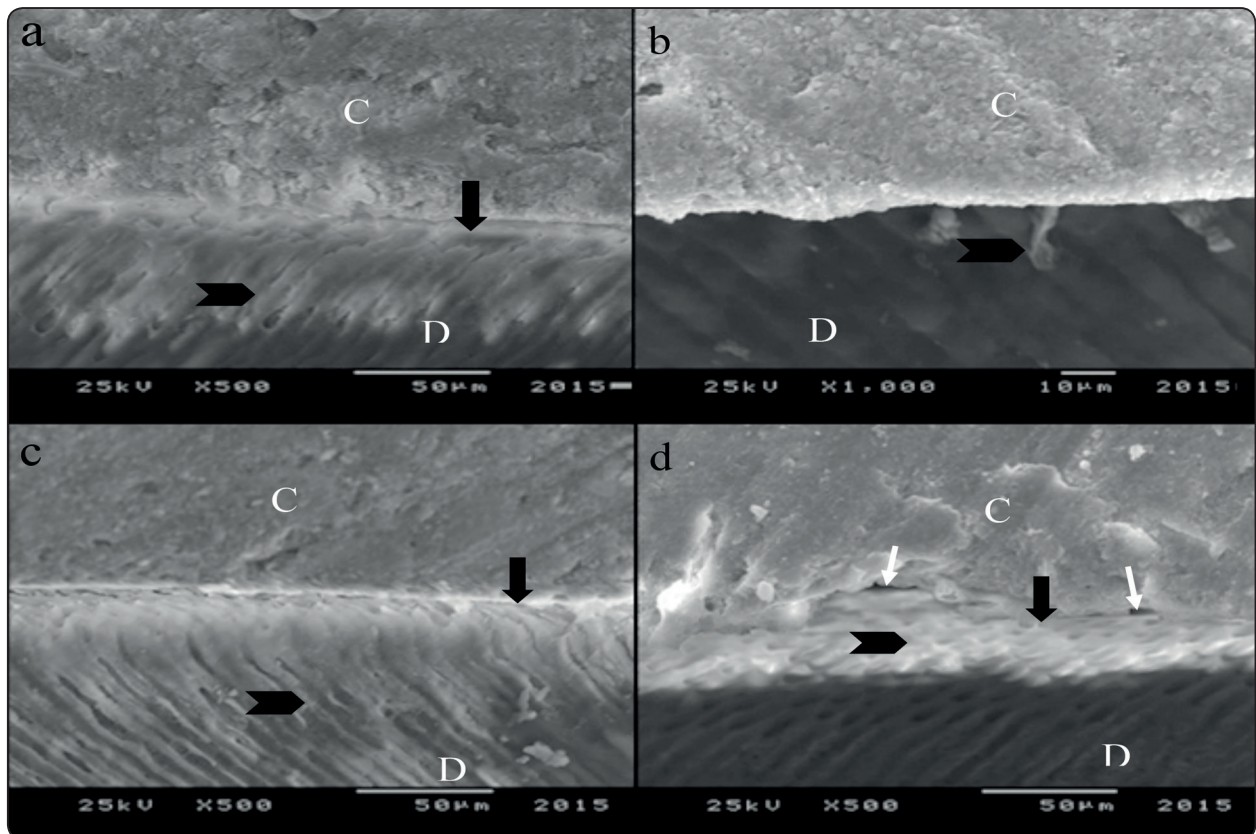


Fig (1) Representative scanning electron microscopy images of the dentin-adhesive/material interface. (a) Dyad Flow, (b) Fusio Liquid Dentin, (c) Vertise Flow, (d) OptiBond All-In-One + Permise Flowable. C: Composite resin, D: Dentin. The chevrons indicate resin-impregnated dentinal tubules. The black arrows point out hybrid layers. The white arrows point to minute gaps at adhesive-composite interface.

DISCUSSION

Recent research advancements has mainly aimed at reducing technique sensitivity and chair time.^(3,4,13,16) From this point of view, the elimination of a bonding step can be considered a great

breakthrough. Therefore, it seemed reasonable to consider the all-in-one adhesive followed by the application of conventional flowable composite as the comparative product group for this newly developed self-adhering flowable resin

composites.⁽²⁾ According to the findings of this study, the formulated null hypothesis has not to be rejected, since the μ SBS values of all self-adhering flowable composites were not significantly different from that of conventional flowable composite bonded with all-in-one adhesive. Also, all materials showed similar marginal adaptation.

Many factors can influence the bonding performance of adhesive systems to dentin, among these are: dentin substrate,⁽³²⁾ dentin treatment,⁽³³⁾ and chemical composition of the adhesive systems.⁽³⁴⁾ All-in-one adhesive systems are currently composed of hydrophilic and hydrophobic monomers and solubilized in water and/or organic solvents, such as acetone or ethanol. Such monomers can penetrate the smear layer and perform a mild demineralization of the underlying dentin, forming covalent bonds with the dentin collagen and ionic bonds with hydroxyapatite.^(35,36)

Self-adhering flowable composite materials used in this study have different acidic functional monomers. Vertise Flow and Dyad Flow relies on glycerol phosphate dimethacrylate (GPDM) as a functional monomer. GPDM adhesive monomer has an acidic phosphate functional group for etching and bonding to tooth structure. It also has two methacrylate functional groups which copolymerize with other methacrylate monomers to form cross-linked polymeric network and to provide increased crosslinking density and enhanced mechanical strength of polymerized adhesive.^(37,38) According to the manufacturers, these materials bonds to tooth structures by two means: firstly through the chemical interaction between the phosphate functional group of GPDM monomer and calcium ions of tooth structure; and secondly through micromechanical bonding as a result of an interpenetrating network formed between the polymerized monomer and collagen fibers (as well as smear layer) of dentin. Micromechanical etching of tooth structure by Vertise Flow and Dyad Flow is facilitated by low

(1.9) pH of the resin material, which is similar to that of mild self-etch adhesives.⁽³⁸⁾ However, the bonding mechanism of Fusio Liquid Dentin, is based on 4-methacryloxyethyl trimellitic acid (4-META). Fusio Liquid Dentin's unique formula is both acidic (pH 3-4) and hydrophilic, which allows the negatively charged carboxylic acid groups of the methacrylate monomers bond to the mineral ions in the tooth structure. As the carboxylic acid groups are neutralized and the monomers polymerized they become incorporated into the dentin surface enhancing both dentin bonding and sealing ability.⁽³⁹⁾ Whereas the bonding mechanism of OptiBond All-In-One adhesive is similar to that of Vertise Flow and Dyad Flow, since it also includes GPDM as a functional monomer in its structure.⁽⁴⁰⁾

A distinctive characteristic of all self-adhering flowable composites and OptiBond All-In-One adhesive used in the present study is the inclusion of hydroxyethyl methacrylate (HEMA) in their chemical formulations. HEMA is a hydrophilic, water-soluble methacrylate priming monomer that enhances the wetting capability of the adhesive solutions. In addition, HEMA prevents phase separation reactions, by promoting the miscibility of hydrophilic and hydrophobic components of the adhesive.^(8,31) Furthermore, it was reported that the inclusion of HEMA in the composition of all-in-one adhesives contributed to enhanced 24-hours bond strength.⁽⁴¹⁾ In another previous study,⁽⁴²⁾ it was pointed out that the lack of HEMA was suggested as a possible explanation for the relatively weak adhesion. Consequently, the inclusion of the same self-etch adhesive monomer (GPDM) in Dyad Flow, Vertise Flow, and OptiBond All-In-One adhesive (groups I, III, and IV) might account for the comparable values of μ SBS of these materials that were obtained in this study. Also, from the results of this study, it can be speculated that the similarity in mode of action of 4-META and GPDM functional monomers might explain the insignificant difference in μ SBS between Fusio Liquid Dentin (group II)

and OptiBond All-In-One adhesive (group IV). It has been reported that 4-META has a good chemical bonding potential to hydroxyapatite,⁽⁴³⁾ which also might be the reason for the insignificant difference in μ SBS between group II and group IV. The results in the present study are in line with the results of a previous study.⁽⁴⁴⁾ The authors reported that Dyad Flow achieved an equal or higher bond strength to dentin in comparison to that obtained by a separate self-etch adhesives combined with traditional flowable composites. Contrary to our results, Tuloglu et al.⁽⁴⁵⁾ found that the shear bond strength of Vertise Flow self-adhering flowable composite was lower than that of Filtek Ultimate conventional flowable composite bonded with OptiBond All-In-One. This difference may be related to the variation in aging procedure. In that previous study, SBS was assessed after thermal aging, while in the present study μ SBS was measured after 24 hours without considering aging.

In respect to interfacial morphology that was revealed by SEM observations, all tested materials appeared well adapted to dentin. Our results are in line with the results of a previous investigation⁽²⁾ concerning Vertise Flow and OptiBond All-In-One. In that study, it was stated that hygroscopic expansion and relatively low polymerization contraction might be advocated as possible reasons for satisfactory sealing performance. In another researches,^(46,47) it has also been demonstrated that Vertise Flow undergoes hygroscopic expansion. As to hygroscopic expansion, it is documented that acidic resin monomers absorb higher water than neutral resin monomers.^(48,49) Recently, Wei et al.,⁽⁴⁶⁾ pointed out that Vertise Flow has a higher hygroscopic expansion than UDMA-based polymers due to the hydrophilic acid phosphate group and the spacer group in GPDM monomer. Hence, it can be supposed that the hygroscopic expansion of self-adhering flowable composites used in the present study might have participated to the satisfactory marginal adaptation showed by the materials if it

is actually equalized polymerization shrinkage. Vichi et al.,⁽²⁾ reported that the acceptable sealing performance showed by Vertise Flow in their study can also be related to the uniqueness of the dynamics in its adhesion/polymerization process. During restoration procedure of conventional resin composite materials, the bonding agent and the restorative composite are placed in sequence, therefore the restorative composite polymerization occurs after bonding is achieved. The bond that just created by the adhesive with the dental substrate may be inhibited by the polymerization stress of the restorative composite.⁽⁵⁰⁾ However, In case of self-adhering composite Vertise Flow, bonding and polymerization of the resin occur concurrently.⁽²⁾ The authors speculated that as the viscous-elastic flow can occur simultaneously with the bonding process, competition between bonding and polymerization stress is decreased, thus promoting marginal adaptation of the material. Consequently, such behavior; in addition to, hygroscopic expansion might be accounted for the meticulous marginal adaptation appeared by all tested materials in the present study, which might in turn also have a positive reflection on bond strength.

Although a well-defined resin-impregnated dentinal tubules layer was observed in SEM image (Fig. 1d) of OptiBond All-In-One adhesive, a more deeper resin infiltrations was evident in the images (Fig 1a and 1c) of Dyad Flow and Vertise Flow, whereas minimal short resin infiltrations without distinct hybrid layer could be seen in the image (Fig 1b) of Fusio Liquid Dentin. The possible explanation for such performances could be attributed to the difference in the acidity (pH) between these materials, where the acidity (pH 1.9) of Vertise Flow and Dyad Flow^(37,38) is higher than the acidity (pH 2.5) of OptiBond All-In-One adhesive,⁽⁴⁰⁾ which in turn is higher than the acidity (pH 3-4) of Fusio Liquid Dentin.⁽³⁹⁾ These results agree with those of Poitevin et al., 2013⁽⁵¹⁾ and Fu et al., 2013⁽⁵²⁾ in respect to Vertise Flow. It was reported, in that studies, that

the high acidity of Vertise Flow leads to opening the dentinal tubules and exposes the collagen network, which is similar to the effect of etch-and-rinse method using phosphoric acid. The fewer discrete resin tags that are observed in scanning electron micrographs of Fusio Liquid Dentin sections may also be due to the path of sectioning was parallel to the dentinal tubules.⁽⁵³⁾ However, the minute gaps that were noticed in the image (Fig. 1d) of Opti-Bond All-In-One at adhesive-composite interface might be due to the incomplete polymerization of resin due to presence of residual water, as residual water may be retained due to its low vaporization in the presence of HEMA.⁽⁵⁴⁾

CONCLUSION

Within the limitations of this in vitro study it can be concluded that the new self-adhering flowable composites (Vertise Flow, Dyad Flow, Fusio Liquid Dentin) achieved statistically similar micro-shear bond strength to dentin, which were comparable to that obtained with a combination of all-in-one adhesive and conventional flowable composite (Optibond All-In-One + Premise Flowable). All materials tested exhibited a continuous interface and appeared well-adapted to dentin substrate. However, additional investigation under clinical conditions are required to confirm the results achieved from this in-vitro study.

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