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# MICROLEAKAGE EVALUATION OF SELF-ADHESIVE RESTORATIVE MATERIALS APPLIED WITH DIFFERENT BONDING TECHNIQUES (AN IN-VITRO STUDY)

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## *ABSTRACT*

**Aim:** This study was conducted to evaluate the microleakage around class V restorations of two self-adhesive restorative materials applied with different bonding techniques.

**Materials and methods:** 60 Class V cavities were prepared on sound extracted molars then randomly divided into two groups according to the type of self-adhesive restorative materials tested (A); (A1): Surefil one™ bulk fill composite hybrid and (A2): Vertise™ Flow resin composite. Each group was subdivided into three subgroups of according to the bonding technique utilized (B); (B1): Selfadhesive restorative material alone, (B2): Acid etch+ Self-adhesive restorative material, and (B3): Acid etch+ adhesive system+ Self-adhesive restorative material. After restoring Class V cavities, specimens were immersed in methylene blue solution for four hours. Then specimens were sectioned at bucco-lingual direction through the center of the restorations. The tooth restoration interface was examined at the occlusal and cervical margins and dye penetration was measured in micrometer under a stereomicroscope.

**Results:** Surefil One showed higher statistically significant microleakage mean values compared to Vertise Flow. In addition, the cervical margins showed higher microleakage mean values compared to the occlusal margins. Acid etch+ adhesive system+ Selfadhesive restorative material bonding technique showed the lowest statistically significant microleakage mean values with both tested material compared to other bonding techniques.

**Conclusions:** Vertise Flow self- adhesive resin composite had better sealing ability to class V prepared cavities when compared to Surefil One bulk-fill composite hybrid. Universal adhesives with prior etching step improved the sealing ability of the tested self-adhesive restorative materials.


**KEYWORDS:** Microleakage, Self-adhesive, Vertise Flow, Surefil one, Stereomicroscope

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## INTRODUCTION

Major challenges in restorative dentistry are the longevity of class-V fillings and preventing microleakage around cervical fillings, predominately when there isn't any enamel at the cervical site.[1]

The passage of liquids, ions, chemicals, and germs via the tooth-restoration contact is known as microleakage[2]. Under restorative materials, it is the primary cause of secondary caries development and tooth hypersensitivity. Bacterial toxins in microleakage can potentially result in pulpal inflammation in vital teeth. The restoration's durability is also shortened by bacterial aggregation at the tooth-filling space or inside the dentinal tubules.

The ongoing development in tooth-colored restorative materials and adhesive systems is directed to lower microleakage, promote technical simplicity, shorten the processes involved in the procedure, and increase their adhesion[3].

One of the main goals of dental adhesive development has been to simplify the bonding processes in resin composite restorations[4], in which the washing step is eliminated, which considerably lowers the clinical procedure period and error risk[5].

It was claimed that the marginal seal obtained from these simplified adhesives is suitable and similar to conventional systems[6]. Universal or multi-mode bonding substances are the latest category of bonding substances that are currently entered in the dentistry market. They serve as self-etch bonding substances that may be utilized in a single step and can be employed with or without an extra etching procedure. Because they contain monomeric constituents that may chemically adhere to healthy natural teeth, the universal or multi-mode adhesives consequently provide the dentist flexibility during the placement of composite fillings[7].

Improvement in the resin composite restoration is in parallel to the improvements in the adhesive systems. A new category of resin composite was introduced what is called the "self-adhesive composites" which can simplify the direct restoration process by combining the characteristics of resin composites with self-etch substances, removing the prerequisite for a bond placement[7].

These self-adhesive filling materials are often found in the market as bulk-fill composite hybrids (Surefil one™ Dentsply, USA) or as flowable composite (Vertise™ Flow, Kerr corporation, USA). The bulk-fill resin composites have been created just for a single application. Depending on the brand, these materials can be inserted in a 4 or 5-mm bulk placement without requiring a considerable polymerization period. Therefore, this bulk-fill material eliminates incremental techniques and reduces both the working time and clinical steps required[8]. It was claimed by the manufacturers that self-adhesive composites have the benefits of reduced postoperative sensitivity, reduced errors, and provide good esthetics[9].

The microleakage susceptibility of modern self-adhesive filling substances in class-V lesions has not received sufficient focus in the published studies. So; the present research was conducted to assess the microleakage around class V fillings (occlusal and cervical margins) of two self-adhering filling substances with different bonding techniques[10].

The research's null hypothesis was that the examined self-adhesive restorative materials at the occlusal and cervical margins of class V with various bonding procedures had no variation in microleakage values.

## MATERIALS AND METHODS

Two self-adhesive restorative materials and two adhesive systems were tested in this study: Surefil one™ : a self-adhesive bulk fill composite hybrid was utilized with Prime&Bond universal™ Universal Adhesive. Vertise™ Flow: self-adhering flowable resin composite was utilized with OptiBond™ Universal adhesive. Table (1) showed materials used, composition, lot number, and manufacturers.

**1. Teeth selection:**

A total of Thirty recently extracted human molars removed for periodontal reasons were collected. Extracted molars were selected from middle-aged group patients 25 to 40 years after the research protocol was analyzed and approved by the Ethical Research Committee of the Faculty of Oral and Dental Medicine, Minia University.

The teeth were cleaned with a sharp hand scaler (Prima-Dent, International, Frankfurt, Germany) under running tap water to remove any remaining periodontal fibres and blood. The teeth were also examined for cracks, caries, fractures, cervical abrasion, and any structural defects using a magnifying lens (Bausch and Lomb, Opt. Co. Rochester, NY, USA), and only teeth free from any fault were picked, and lastly polished with polishing paste and brush attached to low-speed hand piece (W&H, WA-66A, dentalwerk, Bürmoos, Austria).

TABLE (1) Materials used, composition, lot number, and manufacturer.

| Material | Composition | Lot Number | Manufacturer |
|---|---|---|---|
| **Surefil one**<br>**Self-adhesive bulk-fill composite hybrid** | Powder: dispersed silicon dioxide,silanated aluminum-phosphor-strontium sodium- ytterbium fluoride,fluoro-silicate glass, pigments.<br>Liquid: polycarboxylic acid, acrylic acid, bifunctional acrylate, self-cure initiator, stabilizer, camphorquinone.<br>**Filler content**: 77%wt | 2201000711 | Dentsply, USA |
| **Prime & Bond Universal Adhesive** | Bi- and multifunctional acrylate<br>PENTA*<br>10-MDP**<br>Active Guard™ Technology crosslinker, tertiary amine,<br>10–24.5% Isopropanol,<br>5–24.5% water. | 2302000151 | |
| **Vertise flow**<br>**Self-adhesive composite** | **Matrix**: adhesive monomer GPDM.<br>**Filler**: barium glass fillers1$\mu$, pre-polymerized fillers 20$\mu$, nano-sized colloidal silica fillers10-40nm, nano-sized Ytterbium fluoride fillers 40nm.<br>**Filler content**: 70%wt | 8518634 | Kerr corporation, orange, CA, USA |
| **OptiBond Universal adhesive** | **Monomers:**<br>Self-etching adhesive monomer (GPDM)*** - Co-monomers including mono- and di-functional methacrylate monomers.<br>**Solvents:** acetone, alcohol, and water.<br>**Photo-initiator:** (CQ)****-based photo-initiator system<br>**Fillers:** three nano-sized fillers Fluoride-releasing fillers – sodium exafluoro-silicate and ytterbium fluoride. | 9100949 | |
| **Meta Etchant gel** | Etching gel contains 37% phosphoric acid in water, colorants, and a thickening agent. | MET1906071 | Meta Biomed<br>Germany |

***PENTA: (dipentaerythritol pentacrylate phosphate)** ***10-MDP: (10-methacryloyloxydecyl dihydrogen phosphate)**

****GPDM: (Glycerol phosphate dimethacrylate)** *****CQ: (Camphorquinone based photo-initiator)**

The teeth were then kept at 4°C for a maximum of one month before being employed in phosphate buffer solution (g/L): [(Na2HPO4 (0.578), KH2PO4 (0.353) mixed in distilled water containing 0.02% sodium azide] adjusted at PH=7[10].

**2. Specimens preparation:**

Sixty class V cavities with measurements of approximately (4 mm±0.5 mesio-distally, 2 mm± 0.5 occluso-gingivally and 2 mm±0.5 in depth)[11,12] were prepared in the buccal and lingual aspects of the 30 selected molars.

A Tofflemire metal band (Hawe, Kerr Dental, CA, USA) modified with a window of (4mm mesio-distal, 2mm occluso-gingivally) was retained around the tooth by a Tofflemire retainer adapted 1mm above the cervical line on the labial and lingual aspects of the extracted teeth[13]. Class V cavities were prepared with #330 carbide bur (Hager and Meisinger GmbH, Neuss, Germany) fixed to a high-speed hand piece (Sirona T4, Germany) with water coolant system[14,15]. A new bur was used for each five prepared class V cavities to eliminate dullness. There were no bevels formed at any of the prepared cavity enamel margins[16].

A graduated periodontal probe (Hu-friedy, Chicago, USA) was used to check the measurements of the prepared cavities[17]. Following the preparation of the cavities, all specimens were directly dipped in distilled water until restoration.

**3. Grouping of the specimens:**

The 60 Standardized classes V cavities were divided randomly into two groups of (30 specimens) each according to the type of resin composite tested (A); ($A_1$): Surefil one™ bulk fill composite hybrid and ($A_2$): Vertise™ Flow resin composite. Each group was subdivided into three subgroups of 10 specimens each according to the bonding technique utilized (B); ($B_1$): Self-adhesive restorative material alone, ($B_2$): Acid etch+ Self-adhesive restorative material, and ($B_3$): Acid etch+ adhesive system+ Self-adhesive restorative material.

**4. Restorative procedure:**

**Each prepared cavity was restored Following the manufacturer's recommendations.**

In subgroup $A_1B_1$, Surefil composite was utilized alone (without using acid etch or bonding agent). It was supplied in the form of capsules where the red activation button was pressed against a hard surface to activate the capsule, mixed in an amalgamator (Silamat S6 Amalgamator, Ivoclar, Vivadent, USA) at (4500 rpm) for 10 sec then placed in an extruder, followed by application of the material in bulk of 2 mm in the prepared cavity while keeping the nozzle in the material during application till overfill the cavity. The excess material was removed using a composite applicator and light-cured for 20 sec using an LED light-curing unit (Elipar curing unit, 3M ESPE St. Paul, USA) with a light intensity of 800 mW/cm$^2$.

In Subgroup $A_1B_2$, Surefil one composite was utilized after the application of an acid etch. The prepared cavities' enamel and dentin walls were first etched with 37% phosphoric acid for 15 sec, then were rinsed with water spray for 15 sec followed by blot drying using a mini-sponge. Surefil one composite was then applied onto the prepared cavities as mentioned before.

In subgroup $A_1B_3$, Surefil one composite was utilized after the application of acid etch and Prime&Bond universal adhesive. Following etching, the Prime&Bond universal adhesive was applied onto the prepared cavities and then agitated for 20 sec utilizing a disposable micro-brush. To evaporate the solvent, the adhesive layer was air-thinned for 5 sec using minimal, oil-free compressed air, then light-cured for 10 sec. Surefil one composite was then applied onto the prepared cavities as mentioned before.

In subgroup $A_2B_1$, Vertise flow composite was utilized alone (without using acid etching or bonding agent). Using a tiny microbrush, the initial thin coating layer (0.5 mm thickness) was applied to the prepared within 15–20 sec. It was then light-cured for 20 sec. A further layer of Vertise flow composite, less than 2 mm thick, was added to the remaining cavity space, and it was cured for 20 sec.

In subgroup $A_2B_2$, Vertise flow composite was utilized after the application of an acid etch. Enamel and dentin walls of the prepared cavities were first etched for 15 sec using 37% phosphoric acid, and then washed for 15 seconds using water spray followed by blot drying using a mini-sponge. Vertise flow self-adhesive resin composite was then applied onto the prepared cavities as mentioned before.

In subgroup $A_2B_3$, Vertise flow self-adhesive resin composite was utilized after the application of acid etch and OptiBond universal adhesive. Following etching, the OptiBond universal adhesive was applied to the cavity walls and rubbed with a micro brush for 20 sec. then, air-thinned to evaporate the solvent using soft, oil-free compressed air for 5 sec. followed by light curing for 20 sec. Vertise flow self-adhesive resin composite was then applied onto the prepared cavities as mentioned before.

All restorations were polished using flexible aluminum oxide discs (SofLex, 3M ESPE, St. Paul, MN, USA) following the restoration of the prepared cavities. After that, the samples were kept for a week at 37°C in distilled water until testing.

**5. Assessment of microleakage:**

**Specimen preparation for microleakage test:**

All the specimens' exterior surfaces were painted with two coats of nail varnish (Essence Shine Last and Go, gel nail polish, Germany) using a brush except for the restoration's surface and the area 1 mm beyond its borders. The specimens were then left undisturbed for a day to allow the varnish to dry. Using sticky modeling wax (Cavex, Holland BV, Netherlands), the root apices were sealed. Soaked for four hours at room temperature in a recently made aqueous methylene blue solution with a concentration of 2 gm/200 c.c. water. Specimens were taken out of the methylene blue dye, rinsed under tap water for ten minutes, and then patted dry with tissue paper[18].

**Sectioning of specimens:**

Specimens were mounted to an acrylic resin block to facilitate holding the specimens in the cutting machine. Specimens were split longitudinally in a bucco-lingual direction through the middle of the restoration using Isomet 4000 (IsoMet, 4000 Buehler, Lake Bluff, Illinois, United States) automated diamond saw under cooling system[18]. Sectioned specimens were then washed under tap water and dabbed dry with tissue paper.

**Evaluation of microleakage:**

The occlusal and cervical margins of the tooth restoration interface were examined, and the depth of dye penetration was measured in micrometers using a stereomicroscope (Nikon SMZ745T, Tokyo, Japan) at 40X magnification. An image of the interface was then taken and saved to a computer operating an image analysis software program (Omnimet, Buehler USA).

**6. Statistical analysis:**

The results of microleakage values were recorded and tabulated. Normality exploration of data was done using Shapiro Wilk Normality test and Kolmogorov test. A comparison between Surefil one group and Vertise Flow group was performed by using Independent t test. Comparison between microleakage at the occlusal and cervical margins was performed by using Paired t test. Comparison between different bonding techniques was performed by using One Way ANOVA test followed by Tukey`s Post Hoc test for multiple comparisons. Two Way ANOVA test was used to evaluate the percent of total variance. Statistical analysis was performed with SPSS 20®, Graph Pad Prism®, and Microsoft Excel 2016.

## RESULTS

Mean and standard deviation of all bonding techniques in occlusal and cervical areas regarding Vertise flow group were presented in Table (2). Comparison between different bonding techniques revealed significant differences between them in occlusal and cervical areas, in the occlusal area: Acid etch + Bond + Vertise Flow resin composite bonding technique (331.27±36.44) was significantly the lowest, while Vertise Flow alone used technique(417.15±45.89) and Acid etch + Vertise Flow resin bonding technique (471.76±51.89) were significantly the highest with insignificant difference between them. On the other hand, in the cervical area**:** Acid etch + Vertise Flow resin composite bonding technique (527.91±58.07) was significantly the highest, followed by Vertise Flow alone technique (511.82 ± 56.30) with no significant difference between them. Acid etch + Bond+ Vertise Flow resin composite bonding technique (370.76 ± 40.78) revealed the lowest statistically significant mean microleakage values.

Comparison between the occlusal and cervical margins microleakage mean values in Vertise flow group revealed that: the occlusal margins had statistically significantly lower mean microleakage values compared to the cervical margins with the three tested bonding techniques, at P=0.0001.

Table (3) represents mean and standard deviation of all bonding techniques in occlusal and cervical areas regarding Surefil One group. Comparison between different bonding techniques revealed significant differences between them in occlusal and cervical areas, in the occlusal area: Acid etch + Surefil One bonding technique (825.64±90.82) was significantly the highest, followed by the application of Surefil One alone (693.63±76.30), then Acid etch + Bond + Surefil One bonding technique (362.78±39.91) which revealed the lowest significantly significant mean microleakage values.

TABLE (2) Mean and standard deviation of occlusal and cervical margins mean microleakage values ($\mu$m) with different bonding techniques in Vertise Flow group.

| VERTISE FLOW | Occlusal | Cervical | Paired Differences | | | | P-value |
|---|---|---|---|---|---|---|---|
| | | | M ± SD | SEM | 95% CI | | |
| | M ± SD | M ± SD | | | L | U | |
| **Vertise Flow alone** | 417.15 $^{Aa}$ ± 45.89 | 511.82 $^{Ab}$ ± 56.3 | 391.75 ± 152.90 | 48.35 | -501.13 | -282.37 | 0.0001** |
| **Acid etch + Vertise Flow** | 471.76 $^{Aa}$ ± 51.89 | 527.91$^{Ab}$ ± 58.07 | 276.85 ± 128.24 | 40.55 | -368.59 | -185.12 | 0.0001** |
| **Acid etch + Bond + Vertise Flow** | 331.27 $^{Ba}$ ± 36.44 | 370.76$^{Bb}$ ± 40.78 | 141.18 ± 64.69 | 20.46 | -187.46 | -94.90 | 0.0001** |
| **P-value** | 0.0001** | 0.0001** | | | | | |

***M: mean SD: standard deviation **Highly significant difference as P≤0.001. ns: non-significant difference at P>0.05.***
***MD: mean difference SEM: standard error mean CI: confidence interval L; lower arm U: upper arm***
***Means with the same lower-case superscript letters in each row were insignificantly different at P>0.05.***
***Means with different lower-case superscript letters in each row were significantly different at P≤0.05.***
***Means with the same upper-case superscript letters in each Column were insignificantly different at P>0.05.***
***Means with different upper-case superscript letters in each Column were significantly different at P≤0.05.***

TABLE (3) Mean and standard deviation of occlusal and cervical margins mean microleakage values ($\mu$m) with different bonding techniques in Surefil One group.

| SUREFIL ONE | Occlusal | Cervical | Paired Differences | | | | P-value |
|---|---|---|---|---|---|---|---|
| | | | M ± SD | SEM | 95% CI | | |
| | M ± SD | M ± SD | | | L | U | |
| **Surefil One alone** | 693.63 $^{Ba}$ ± 76.3 | 1085.37$^{Ab}$ ± 119.39 | 94.67 ± 55.11 | 17.43 | 55.24 | 134.09 | 0.0001** |
| **Acid etch + Surefil One** | 825.64 $^{Aa}$ ± 90.82 | 1102.49$^{Aa}$ ± 121.27 | 56.16 ± 83.58 | 26.43 | -115.95 | 3.63 | 0.063 ns |
| **Acid etch + Bond + Surefil One** | 362.78 $^{Ca}$ ± 39.91 | 503.96$^{Ba}$ ± 55.44 | 39.49 ± 62.71 | 19.83 | -84.35 | 5.37 | 0.078 ns |
| *P-value* | 0.0001** | 0.0001** | | | | | |

On the other hand, in the Cervical area: Acid etch + Bond + Surefil One bonding technique (503.96±55.44) was significantly the lowest, while Surefil One alone technique (1085.37±119.39) and Acid etch + Surefil One bonding technique (1102.49±121.27) were significantly the highest with insignificant difference between them.

Comparison between the occlusal and cervical margins microleakage mean values in Surefil One group revealed that: the occlusal margins had statistically significant lower mean microleakage values compared to the cervical margins when Surefil one was applied alone, at P=0.0001. On the other hand, with the other two tested bonding techniques: (acid etch + Surefil One bonding technique and acid etch + Bond + Surefil One bonding technique) occlusal margins microleakage mean values were insignificantly lower than the cervical margins, at *P=0.06* and *P=0.07* respectively.

Regarding comparing the two self-adhesive restorative materials, Mean and standard deviation of different bonding techniques in both groups regarding occlusal area were presented in Table (4). Comparison between both groups revealed that when the self-adhesive restorative materials were applied alone, Vertise Flow group (417.15±45.89) showed statistically significant lower mean microleakage values than Surefil one group (693.63±76.30) with (276.21±30.41) difference between them at P=0.0001. Moreover, in Acid etch + Self-adhesive restorative materials bonding technique: Vertise flow group (471.76±51.89) showed statistically significant lower mean microleakage values than Surefil one group (825.64±90.82) with (353.88±33.08) difference between them at P=0.0001. on the other hand, in Acid etch + Bond + Self-adhesive restorative materials bonding technique: Vertise flow group (331.27±36.44) showed statistically non-significant lower mean microleakage values compared to Surefil one group (362.78±39.91) with (31.51±17.09) difference between them as P=0.08.

On the other hand, Table (5), represents Mean and standard deviation of the two self-adhesive restorative materials applied with different bonding techniques at cervical area. Comparison between both tested materials revealed that Vertise flow group showed statistically significant lower mean microleakage values than Surefil one group at the cervical margins with all bonding techniques tested at P=0.0001.

TABLE (4) Mean and standard deviation of occlusal section in different techniques of both groups, comparison between both groups using Independent t-test:

| OCCLUSAL | VERTISE FLOW | SUREFIL ONE | MD ± SEM | 95% CI | | P-value |
|---|---|---|---|---|---|---|
| | M ± SD | M ± SD | | L | U | |
| **Self-adhesive restorative materials** | 417.15[a] ± 45.89 | 693.63[b] ± 76.30 | 276.21 ± 30.41 | -244.80 | -118.81 | 0.0001 ** |
| **Acid etch + Self-adhesive restorative materials** | 471.76[a] ± 51.89 | 825.64[b] ± 90.82 | 353.88 ± 33.08 | -423.38 | -284.39 | 0.0001 ** |
| **Acid etch + Bond + Self-adhesive restorative materials** | 331.27[a] ± 36.44 | 362.78[a] ± 39.91 | 31.51 ± 17.09 | -67.41 | 4.39 | 0.08 ns |

TABLE (5) Mean and standard deviation of cervical section in different techniques of both groups, comparison between both groups using Independent t test:

| CERVICAL | VERTISE FLOW | SUREFIL ONE | MD ± SEM | 95% CI | | P-value |
|---|---|---|---|---|---|---|
| | M ± SD | M ± SD | | L | U | |
| **Self-adhesive restorative materials** | 511.82 [a] ± 56.3 | 1085.37[b] ± 119.39 | 573.48 ± 55.45 | -753.20 | -583.25 | 0.0001** |
| **Acid etch + Self-adhesive restorative materials** | 527.91[a] ± 58.07 | 1102.49[b] ± 121.27 | 574.58 ± 42.52 | -663.91 | -485.25 | 0.0001** |
| **Acid etch + Bond + Self-adhesive restorative materials** | 370.76[a] ± 40.78 | 503.96[b] ± 55.44 | 133.20 ± 21.76 | -178.92 | -87.48 | 0.0001** |

## DISCUSSION

Resin composite has become one of the most popular materials used to restore teeth. The modern self-adhesive filling substances had the advantage of fewer application steps with subsequent less technique sensitivity compared to conventional resin composites applied in combination with an adhesive system. Manufacturers of these self-adhesive composites claimed that these composites could provide a final restoration with comparable clinical performance to conventional resin composites; combining the advantages of bonding and filling substances together, which offers beneficial prospects to the overall restorative systems[19].

Since Class-V lesions are simpler to standardize than Class-II lesions, the microleakage assessment was conducted in Class-V-prepared cavities in the current study[20]. The dye penetration approach was employed for this investigation due to its great practicability and reproducibility[16].

Regarding the results of the current study; Vetrise Flow self-adhesive composite showed lower micro-leakage mean values compared to Surefill One™ self-adhesive composite at the occlusal and cervical cavities margins with all bonding techniques, except with the acid etch followed with the application of adhesive system at the occlusal margins, there were no statistically significant variation between both materials. These results were in accordance to **Jordehi. et al.,** [4] **and Abd El-Naby et al,**[21].

The reason for the superiority of the adaptation of the Vertise flow resin composite is primarily related to its chemical constituents and the functional monomer included, which is named glycerol phosphate dimethacrylate (GPDM). The phosphate group of GPDM is specifically responsible for acid-etching. Since Vertise Flow's developer states that, its pH is 1.9, thus it was expected that, it would react with dental substrate in a manner like to that of a gentle self-etch adhesive. On the other side, the dimethacrylate functional groups enhanced the mechanical strength at the adhesive contact by getting involved in cross-linking events with the other methacrylate monomers[4,21].

On the other hand, Surefil One is a bioactive smart material, which are self-adhesive material which had the properties of being bulk-fill and fluoride-releasing. The developer stated that its modified polyacid system (MOPOS) is responsible for the crosslinking ability of the structural monomers contained in composite materials together with the self-adhesive capability of the classic polyacid forms known as glass ionomers[22].

This self-adhesive material is mainly dependent on high molecular weight polyacrylic acids for adhesion, which is able to assist smear layer hybridization and ionic interactions between the carboxylic groups of the Modified Polyacid System (MOPOS) and the calcium in the tooth. This mechanism of adhesion is also reported in resin-modified glass ionomers[23]. Although this self-adhesive hybrid bulk-fill resin contains water in its composition, it was reported that some moisture is needed for functional acid activation. It seemed that the ideal dentin moisture level needed for the activation of the functional acids is difficult to be obtained. Therefore, this could justify the high values of microleakage obtained with Surefil One™ self-adhesive composite hybrid[24].

Another important factor that should be considered is the polymerization shrinkage which affects the marginal adaptation of the restoration to the tooth. Monomers conversion into a polymer network, replacing the van der Waals bonds with stronger covalent bonds results in the shrinkage process. This shrinkage leads to internal tensional stress on the surrounding tooth structure and consequential microleakage[23]. With Vertise flow self-adhesive resin composite bonding and polymerization take place at the same time. Therefore, it could be expected that the struggle between the curing stress and the bond strength is minimized as the viscous-elastic flow happens simultaneously with the bonding progression, thus reducing microleakage at the restoration-tooth interface[25].

On the other hand, Surefil One™ seems to had greater polymerization shrinkage compared to Vertise flow, owing to the dual polymerization utilized with it (acid-base polymerization and light-activated polymerization). This could lead to a higher-stresses during polymerization shrinkage especially in cavities with high C-factor as in Class V prepared cavities utilized in this study. The high microleakage mean values of Surefil One™ were also shown in previous studies by **Neves et al,**[23] and **Yao et al,**[26].

Another explanation for the lower micoleakage mean values of Vertise flow self-adhesive resin composite compared to Surefill One™ self-adhesive composite hybrid might be due to the different composition of the two materials. Vertise flow resin composite was a flowable composite that had a lower filler content compared to Surefil One™ composite hybrid, this might lower its viscosity and increase its penetration capacity into the tooth substrate. Moreover, Vertise flow resin composite included nanosized fillers, this reduced particle size increases the surface area of filler particles. This is responsible for the increase in flexural strength and produces a high surface energy at the filler-matrix contact.

In contrast to that of the Surefil One™ composite hybrid, Its submicron filler size, could result in a decrease in flexural strength because of the larger particles that cause a higher stress concentration at the filler-polymer matrix contact, the inadequate stress distribution caused by the formation of stress concentration points resulting from the filler clusters, the presence of interfacial flaws and poor matrix-filler interaction.[27].

In addition, Vertise flow contains pre-polymerized fillers (PPF) which are greater in size to improve the filler volume fraction. PPFs are processed using ground-cured composite containing a variety of submicron particles. The addition of PPF also reduces the polymerization shrinkage and enhances polish ability leading to decreased gap formation at the tooth restoration interface[28].

Furthermore, the hydrophilic acidic phosphate group in the adhesive monomer GPDM might have undergone hygroscopic expansion, which might be responsible for the low microleakage of Vertise flow self-adhesive resin composite. Additionally, the adhesive monomer's short spacer group may have improved marginal adaptation by compensating resin polymerization shrinkage[25].

Regarding the results of the technique of bonding; acid etching followed by universal adhesive application then application of the self-adhesive restorative materials showed the least microleakage mean values with both tested self-adhesives restorative materials.

This bonding technique's superiority may be attributed to the application of a separate etching phase that completely removes the smear layer and smear plugs. This came in accordance with **Margvelashvili M et al**,[29] who suspected this layer may contain contaminants and bacterial residue and is conceived as a weak site of adhesion since it is weakly connected to the underlying substrate. which seriously affects dentin/adhesive bond strength. On enamel, acid etching selectively dissolves the enamel rods, creating microporosities that were readily penetrated by the adhesive by capillary attraction. The best possible adhesion to the tooth substrate is still provided by the micromechanical interlocking of minute resin tags within the acid-etched enamel surface following polymerization[30].

Moreover, several studies recommended using bonding agents before self-adhering composite placement to improve the wettability and their marginal seal at the cavity walls[25,31]. using universal adhesive gave the advantage of providing chemical bonding to the tooth structure. These universal adhesives contained functional monomers: 10-methacryloyloxydecyl dihydrogen phosphate monomer (10-MDP) and GPDM (in Prime & Bond and Opti-Bond Universal adhesives, respectively) which form a chemical bond to the tooth substrate via their phosphate groups, which produces a stable and water-resistant Ca-monomer salt by ionically binding to any calcium connected to the collagen fibrils[21].

In conclusion, the improved micromechanical retention resulting from the wettability of adhesives, in combination with the chemical interaction between the acidic functional monomers present in universal adhesive and the calcium in the tooth structure were the main reason for the lower microleakage mean values of this bonding technique[22]. On the contrary, the higher statistically significant microleakage mean values when the self-adhesive restorative materials were applied alone compared to the application of acid etching+ universal adhesive application before the application of the self-adhesive restorative materials, might be related to the higher filler content and viscosity, no solvent and the poor wettability of these self-adhesive restorative materials. These characteristics restrict this material's capability to penetrate the exposed collagen network[32].

Results of the current study revealed that prior etching of enamel and dentin followed by the placement of the tested self-adhesive materials had higher statistically significant mean microleakage values compared to the acid etching + universal adhesive application + application of the self-adhesive restorative materials bonding technique.

A possible explanation for the high microleakage value with this bonding technique is that Phosphoric acid application followed by the action of the functional monomers in Vertise flow (GPDM) and the modified polyacids (MOPOS) in Surefil One might resulted in excessive etching of both enamel and dentin which was not followed by the penetration of the self-adhesive tested material into the etched surfaces due to their higher viscosity and hydrophobic properties in comparison to the bonding agents utilized in the acid etch+ adhesive system+ self- adhesive restoration application technique groups. The areas that had been considerably demineralized but not totally infiltrated by the resin could be responsible for a defective interfacial seal[33]. Thus, it was shown that this bonding technique was not successful in reducing the microleakage values.

Moreover, phosphoric acid etching could deplete the hydroxyapatite content of dentin[33], which might impair the chemical bond of GPDM functional monomer and MOPOS modified poly acid present in Vertise flow and Surefil One, respectively.

Some studies recommended pre-etching of enamel before application of Vertise flow self-adhesive resin composite using phosphoric acid[25,34]. They explained that acid etching had the advantage of removing the prismless enamel which in turn improves bonding. This contradiction in the results might be due to the different methodologies utilized: as type of teeth, the technique of specimen preparation, the bonding area, and the test utilized. On the other hand, the results of the current study were supported by **Margvelashvili M et al,**[35] and **Schuldt C et al,**[36] who had reported that phosphoric acid pre-treatment had no improved effect on enamel bonding.

Regarding the results of comparing the microleakage value in the occlusal and the cervical margins results showed that occlusal margins had the lower significant microleakage mean values compared to the cervical margins in both tested self-adhesive materials. These results were statistically significant with Vertise flow resin composite with all tested bonding techniques and with Surefil One composite hybrid when applied alone.

This might be due to that the cervical margin had less thickness of enamel layer than the occlusal margin of the prepared cavities. Moreover, differences in the organic nature, histological structure, and the fewer hydroxyapatite crystals with increased fluid content at the cervical margins of dentin could be another reason for the difference in the microleakage mean values between the occlusal and cervical margins. All these factors lead to occlusal dislodgement of resin composite during polymerization contraction resulting in poor adaptation at the cervical margin. These results were in agreement with **Puckette et al,**[37] and **Gupta et al**,[38].

Finally, in the present study, the null hypothesis was rejected as there was a difference in microleakage mean values between the tested self-adhesive restorative materials at the occlusal and the cervical margins of class V with different bonding techniques.

## CONCLUSIONS

Within the limitations of this in vitro study, the following conclusions could be drawn:

1. Vertise Flow self-adhesive resin composite had better sealing ability to class V prepared cavities when compared to Surefil One bulk-fill composite hybrid.
2. Universal adhesives with a prior etching step improved the sealing ability of the tested self-adhesive restorative materials to enamel and dentine substrates.
3. None of the tested bonding techniques eliminated either the occlusal or the cervical marginal microleakage.
4. Preceding phosphoric acid etching without bond application of tooth substrate had an adverse effect on the quality of the seal of the tested self-adhesive restorative materials.

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