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# A COMPARATIVE EVALUATION OF THE EFFECT OF VARIOUS SURFACE TREATMENT ON MICROLEAKAGE OF A SELF-ADHESIVE COMPOSITE AND A CONVENTIONAL COMPOSITE IN CLASS V CAVITIES: AN INVITRO SEM STUDY

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**Abstract**
**Aim:** The present study was conducted to evaluate and compare the microleakage in class V cavities restored with self-adhering and conventional composite with various surface treatments.
**Materials & method:** Class V cavities were prepared on the buccal surface of 81 extracted teeth and randomly distributed into 2 groups, Group A was restored with self-adhering flowable composite (SAC)and Group B was restored with conventional composite (CC). Both Groups were further subdivided into subgroups respectively. Group Al (n=9) = Acid Etching + SAC, Group A2(n=9) = Acid Etching + $8^{th}$ Generation Bonding agent + SAC, Group A3(n=9) = Air Abrasion +SAC, Group A4 (n=9) = Air Abrasion + 8th Generation Bonding agent +SAC, GroupA5 (n=9) = SAC, Group A6 (n=9) =SAC + $8^{th}$ Generation Bonding agent Group BI = 8 Generation Bonding agent + CC, Group B2 = Acid Etching + 8th Generation Bonding agent + CC, Group B3(n=9) = Air Abrasion + 8th Generation Bonding agent + CC Following immersion in methylene blue dye, the samples were sectioned in bucco-lingual direction. The microleakage scores at the occlusal and cervical margins of the cavities were determined using

scanning electron moicroscopy to ascertain, which group presented minimum microleakage and hence superior bonding properties.
**Results:** Conventional composite (Group B2) provides better marginal adaptation at occlusal level when compared to self-adhesive composite and at gingival level Group B3 (conventional composite) was superior to self-adhesive composite.
**Conclusion:** Conventional composite continues to provide better marginal adaptation when compared to self-adhesive composite. Etch and bond procedures as a pre-restoration surface treatment proves to be superior, for both conventional composite as well as self-adhesive composite.
**Keywords:** Glycerol dimethacrylate dihydrogen phosphate, Self-adhesive flowable resin composites, self-etch adhesives, Scanning electron microscope

**Introduction:** Increased demand for direct aesthetic restorations has resulted in an escalating use of resin composite materials. Despite the improvement of restorative materials and techniques in the recent decades, the postoperative sensitivity with composite restorations remains a challenge for dentistry till date.[1] Composite restorative materials undergo significant volumetric shrinkage when polymerized (1.35% to 7.1%).[2]

The dimensional stability of the tooth/ restoration interface is challenged from the very beginning.[3] The possibility of marginal failure in composite resin restorations is related, mainly to the compromised bond between the dental substrate and the resin, and also to stress generated within the restoration due to polymerization shrinkage.[1]

The most acceptable method to improve the bonding of a composite restoration is to improve the bonding protocol.[4] Although, total-etch and rinse systems remain the gold standard in adhesive dentistry, advancements in the fields of self-etch and self-adhesive systems are now able to create bond strengths that can meet current clinical restorative standards of practice where at the same time having benefits like requirement fewer clinical steps thereby, making it more user friendly.

The latest 8$^{th}$ generation 2 bottle system eg VOCO Futurabond DC provides bond strength as high as 22 – 37 MPA.[4] These nano-bonding agents claim to have superior bond strength to enamel as well as to dentin, in addition to better stress absorption properties and longer shelf life.[5]

The “self-adhesive flowable composites” are much less viscous than traditional composites and are able to “flow” and adapt well to the walls and floors of preparations or to the occlusal pits and grooves such as in sealants.[5]

Constic®, the self-adhering flowable composite used in this study, uses 10 MDP as the adhesive monomer. The monomer contains a phosphate functional group that acts as an etchant and creates a chemical bond with the calcium ions of the tooth. The GPDM monomer also has two methacrylate functional groups for copolymerization and crosslinking with other methacrylate co-monomers.[6]

Acid etching has two primary purposes: 1) it increases the microtopography or surface area of the bonding surface and 2) removes or modifies the smear layer in dentin. Both have the same goal: to increase micro-mechanical retention and to allow a deeper penetration of the adhesive.[7]

Air abrasion removes minimal amount of tooth structure using a stream of aluminium oxide particles generated from compressed air or bottled carbon dioxide or nitrogen gas. Generally, air pressures range from 40 to 160 psi. The recommended levels are at 100 psi for cutting and 80 psi for surface etching. The most common particle sizes are either 27 or 50 µm in diameter.[8]

As there is no substantial data available, evaluating the marginal adaptation of self-adhesive composite, hence this in-vitro microleakage study was initiated to evaluate and compare the marginal adaption of the recently introduced self-adhesive flowable composite with conventional flowable composite using various surface treatments (8$^{th}$ generation bonding, acid etching with dentin bonding agent, air abrasion with dentin bonding agent) thus contributing to the uniqueness of the research.

**Materials and method:** The sample size was calculated using G*Power 3.1.9.7 software. The test family was Chi-square. The sample size was calculated assuming the large effect size (0.5, according to Cohen). The sample size was calculated to achieve the 80% power of the study. The margin of error was set at 5%.

81 sound human premolar teeth were selected for the study which were free of caries, cracks, fracture or restoration, that were extracted 5 months prior to the study due to any orthodontic purposes, denture requirement, or owing to periodontal pathologies. The teeth were scaled for surface debridement, were then immersed in Thymol solution at 4degree C for 7 days and were stored in distilled water at room temperature (25degree C) till further use.

**Preparation of Samples:** Class V cavities were prepared on the buccal surface of each tooth using a high-speed flat-end straight diamond point (SF-41ISO109/010 Mani Dia-Burs) with water as coolant. The cavities had dimensions of 3mm mesiodistally, 3mm occlusogingivally, and a depth of 1.5mm. The gingival portion of the preparation extended below the cementoenamel junction (CEJ). Measurements were taken using a periodontal probe in millimeters.

**Sample testing and methodology:** The teeth were randomly divided into 2 groups and each group was further divided into subgroups

**Group A1:** Surface treatment of the cavity walls with 37%phosphoric acid followed by restoration of cavity with Constic self-adhesive composite.

**Group A2**: Surface treatment of the cavity walls with 37%phosphoric acid, application of eight generation bonding agent followed by restoration of the cavity with Constic self-adhesive composite.

**Group A3:** Surface treatment of the cavity walls with air abrasion followed by restoration of the cavity with Constic.

**Group A4:** Surface treatment of the cavity walls with air abrasion, application of eight generation bonding agent followed by restoration of the cavity with Constic.

**Group A5:** Cavity restored with self-adhesive composite without any prior surface treatment.

**Group A6:** Cavity restored self-adhesive composite with after the application of eight generation bonding agent.

**Group B1:** Cavity restored with conventional flowable restorative composite after the application of eight generation bonding agent

**Group B2:** Surface treatment of the cavity walls with 37% phosphoric acid, application of eight generation bonding agent followed by restoration of the cavity conventional flowable restorative composite.

**Group B3:** Surface treatment of the cavity walls with air abrasion, application of eight generation bonding agent followed by restoration of the cavity conventional flowable restorative composite.

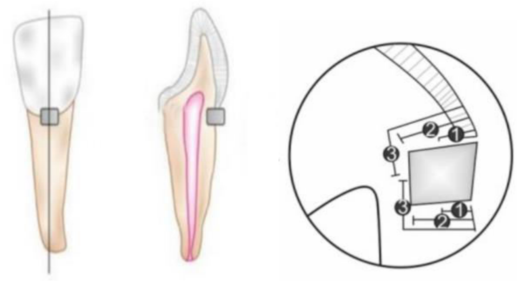
A thin layer of composite, less than 0.5mm thick, was applied to all cavity walls, followed by incremental placement. Subsequently, all the restorations were light-cured for 20 seconds using a light-curing unit. Finally, they were polished using a composite polishing kit (Soflex 3M ESPE).

The root apices and tooth surfaces were sealed with two layers of acetone-based nail varnish, leaving a one-millimeter gap from the restorative margins. The samples were then left undisturbed for one day to allow the varnish to dry.

The prepared tooth samples were immersed in 2% methylene blue and incubated at 37°C for 24 hours. Afterwards, they were rinsed under running water to remove excess dye. The teeth were then sectioned into two halves bucco-lingually along their long axis using a diamond disc to assess micro-leakage at the cervical and occlusal margins.

For each type of samples, the section with greater leakage was selected for scoring.

Microleakage scores were determined based on dye penetration depth at the occlusal and gingival margins, following the method by Silveira de, Araujo et al. The tooth hard tissues and restorative material interface was examined using a scanning electron microscope (SEM) and photographed under magnification to evaluate the extent of microleakage.



| Score | Micro-leakage |
|---|---|
| 0 | No dye penetration |
| 1 | Dye penetration up to one third of the cavity depth |
| 2 | Dye penetration up to two thirds of the cavity depth |
| 3 | dye penetration to the pulpal floor/ axial wall |

**Results:** Table 1. Comparison between occlusal and gingival score.

| Group | Occlusal score | | Gingival score | | Z- value | p-value |
|---|---|---|---|---|---|---|
| | Median | Inter-quartile range | Median | Inter-quartile range | | |
| Group A1 | 3.0 | 3.0-4.0 | 3.0 | 3.0-4.0 | -.447 | .655 |
| Group A2 | 2.0 | 2.0-4.0 | 3.0 | 2.0-3.0 | -.322 | .748 |
| Group A3 | 0.0 | 0.0-1.0 | 0.0 | 0.0-1.0 | .000 | 1.000 |
| Group A4 | 1.0 | 1.0-2.0 | 1.0 | 1.0-2.5 | -.879 | .380 |
| Group A5 | 0.0 | 0.0-1.0 | 1.0 | 0.0-1.0 | -1.000 | .317 |
| Group A6 | 0.0 | 0.0-1.0 | 0.0 | 0.0-1.0 | -.577 | .564 |
| Group B1 | 0.0 | 0.0-1.0 | 0.0 | 0.0-1.0 | .000 | 1.000 |
| Group B2 | 0.0 | 0.0-0.0 | 0.0 | 0.0-1.0 | -1.000 | .317 |
| Group B3 | 0.0 | 0.0-0.5 | 0.0 | 0.0-1.0 | -1.414 | .564 |

Wilcoxon sign rank test.

In all the groups, the gingival score was either greater or equal to the occlusal score, however, the difference was statistically non-significant (p-value>.05).

Table 2. Post hoc analysis.

| Pair-wise | Occlusal score |
|---|---|
| Group A1 vs. Group A2 | .657 |
| Group A1 vs. Group A3 | <.001* |
| Group A1 vs. Group A4 | .055 |
| Group A1 vs. Group A5 | <.001* |
| Group A1 vs. Group A6 | <.001* |

| | |
|---|---|
| Group A1 vs. Group B1 | <.001* |
| Group A1 vs. Group B2 | <.001* |
| Group A1 vs. Group B3 | <.001* |
| Group A2 vs. Group A3 | .001* |
| Group A2 vs. Group A4 | .141 |
| Group A2 vs. Group A5 | <.001* |
| Group A2 vs. Group A6 | <.001* |
| Group A2 vs. Group B1 | <.001* |
| Group A2 vs. Group B2 | <.001* |
| Group A2 vs. Group B3 | <.001* |
| Group A3 vs. Group A4 | .021* |
| Group A3 vs. Group A5 | .620 |
| Group A3 vs. Group A6 | 1.000 |
| Group A3 vs. Group B1 | .755 |
| Group A3 vs. Group B2 | 1.000 |
| Group A3 vs. Group B3 | .755 |
| Group A4 vs. Group A5 | .071 |
| Group A4 vs. Group A6 | .021* |
| Group A4 vs. Group B1 | .009* |
| Group A4 vs. Group B2 | .021* |
| Group A4 vs. Group B3 | .009* |
| Group A5 vs. Group A6 | .650 |
| Group A5 vs. Group B1 | .419 |
| Group A5 vs. Group B2 | .620 |
| Group A5 vs. Group B3 | .419 |
| Group A6 vs. Group B1 | .755 |
| Group A6 vs. Group B2 | 1.000 |
| Group A6 vs. Group B3 | .755 |
| Group B1 vs. Group B2 | .755 |
| Group B1 vs. Group B3 | 1.000 |
| Group B2 vs. Group B3 | .755 |

*p-value<.05 was considered statistically significant.

The paired test was applied to compare the occlusal and gingival microleakage scores of the same group were done. It was shown that there was no significant difference between the microleakage at occlusal and gingival margins for each group even though the gingival score was more compared to occlusal score for all restorative groups

The occlusal score and gingival score were found to differ significantly between the groups (p-value <.05).

The occlusal score in decreasing order: A1 > A2 > A4 > A3 = A5 > A6> B1 > B3 > B2

The gingival score in decreasing order: A1 > A2 > A4 > A5 > A3 = B3> A6> B1=B2

**Discussion:** One of the main factors responsible for defects at the marginal and internal interfaces of composite restorations is the polymerization shrinkage which is an inherent property of the material.

In this study, dye penetration, Methylene blue was used for immersion of the samples for 24 hours as it penetrates further and has a smaller molecule size (0.5–0.7 mm) and it has been observed that the immersion period and marginal gap have a strong correlation.[9]]

In the present study, a well-established in vitro system for the evaluation of the marginal and internal adaptation of restorative materials was used where the tooth - restoration interface was examined under SEM at 100 × magnification.

Class V cavities were evaluated in this study because they do not require macromechanical undercuts and are completely dependent on the bonding mechanism.Restorations of such cervical lesions is challenging since part of their margin is in the enamel and part of it is in dentin or cementum.[10]

The composite Constic (DMG) used in the study is, an innovative resin-based material, combining the properties of self-adhesion and flowability. It claims to eliminate the need for separate step involving acid etching and application bonding agent, thus simplifying the direct restorative procedure.[11]

When comparing the microleakage of self-adhesive composite (GroupA5) and conventional composite (Group B1), bonded following manufacturer's instructions, ie without incorporating any additional surface treatment, conventional composite (B1) showed lesser microleakage when compared to self-adhesive composite (A5). However, the difference in the results were non-significant. The self-adhering composite was found to be less dimensionally stable, due to the incorporation of hydrophilic monomers.[12]

The self-adhesive composite when used in combination with prior treatment with 8th generation bonding agent (Group A6) showed numerically lower values of microleakage than when it was used without any pre-treatment (Group A5), though the results were statistically non-significant. This may be explained by the fact, that when the self-adhesive composite is used without a self-etch bonding agent, it results in incomplete removal of the smear layer and insufficient micromechanical retention between the restoration and tooth structure owing to the limited etching capacity of the self-adhesive flowable composite and low flowability compared to bonding agents. Consistent with our findings, Asefzadeh et al.[13] and Sadeghi et al.[14] demonstrated that application a self-etch bonding agent prior to use of self-adhesive composite in a class V cavity reduces enamel margin microleakage.

When comparing the microleakage of conventional composite and self-adhesive composite (Group A6) with prior application of 8th generation bonding agent, the microleakage values of self-adhesive composite, though found to be inferior to conventional composite (Group B1), the difference was statistically non-significant. The results of the present study, are however, in contrast to a study conducted by Jankovic O et al.[15] who reported improved marginal seal of self-adhering composite (Vertise Flow) compared to conventional flowable composite (Tetric flow) when used in conjunction with a self-etch bonding agent.

Acid etching prior to application of self-adhesive composite (Group A1) showed significantly superior marginal adaptation and minimal microleakage when compared to restoration of cavity with self-adhesive composite alone (Group A5), which could be attributed to the fact that acid etching enables to achieve optimal bond strength by smear layer removal and aids in creations of micro tags.[16]

The results of the present study also revealed that acid etching followed by application of 8th generation bonding agent provided numerically superior occlusal and cervical marginal sealing for both self -adhesive composite (Group A2) and conventional composite (Group B2) although the difference was statistically non-significant. Acid etching is believed to eliminate the smear layer, inducing superficial dentin demineralization and degradation.[16] When compared to the self-etch mode, phosphoric acid usage leads to increased resin tag formation by dissolving some intratubular mineral deposits.

The self-adhesive composite exhibited minimal microleakage when bonded using acid etching followed by bonding agent application (Group A2), and the results were statistically comparable but numerically superior to Group A4 where air abrasion was followed by bonding agent application.

The findings of this study are also in agreement with a study by Atoui et al.,[17] which revealed that conventional turbine preparation with an etch-and-rinse system was still preferable to air abrasion preparation at dentin/cementum margins. They suggested that the indiscriminate action of the particle stream in air abrasion can lead to surface roughness, tubule obliteration, and the absence of resin tags, affecting the adhesive layer and marginal seal.

The microleakage values with Group A2 was found to be statistically significantly lower than in Group A3 where air abrasion was used alone. In this study the higher microleakage values observed with air abrasion alone is in consonance with a study conducted by Freeman et al.[18] where the formation of marginal gaps may be attributed to polymerization shrinkage which is not effectively compensated by air abrasion induced surface roughness; may be this is due to superficial maceration of collagen fibers and tearing of dentin surface by air abrasion.

Comparable microleakage was observed with self-adhesive composite when air abrasion was used alone i.e. Group A3 when compared to Group A4 where air abrasion was followed by 8th generation bonding agent application, prior to placement of self- adhesive composite. This reveals that air abrasion as a pre-restoration treatment step is not effective alternative for improving adaptation of composite to tooth structure.

In all cohorts, the gingival scores were equal to or greater than the occlusal scores, yet the disparity lacked statistical significance ($p > .05$). The findings of the study suggest that both composites exhibit satisfactory bonding with minimal microleakage at the occlusal margin where ample enamel is present, compared to the gingival margin. Bonding in dentin margins is more complex due to dentin's hydrophilic nature and lower mineral content than enamel.

The results of the current study revealed that none of the flowable composite materials were completely devoid of microleakage This finding is in agreement with some studies: Jang et al.,[19]Chimello et al.,[20] and Monticelli et al.[21] reported greater microleakage scores at the occlusal margins than cervical margins. However, Estafan et al.[22] found no difference in occlusal or cervical microleakage of cavities restored with flowable composite resins.

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