The Influence of Silanes on Microleakage in Class V Compomer-filled Cavities

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The purpose of this study was to compare microleakage in class V compomer-filled cavities following application of different adhesives and an additional silane treatment. Standardized class V cavities were prepared in 40 human extracted third molars. The teeth were randomly assigned to four groups (n=10). The cavities were conditioned as follows: Group 1 - Xeno III. Group 2 - 34% phosphoric acid and Prime&Bond NT adhesive. Group 3 - 34% phosphoric acid, followed by 1% silane solution and Prime&Bond NT adhesive. Group 4 - no conditioning procedure was performed. All cavities were filled with compomer (Dyract Extra). The specimens were then stored one week in distilled water (37°C) and thermocycled (1000X) between 5-55°C. After immersion in 2% basic fuchsin, microleakage was evaluated and data were analysed using Kruskal-Wallis and Mann-Whitney U tests. At both occlusal (enamel) and gingival (dentin/cementum) interfaces, statistically significant differences were found among groups (P<0.001). The additional silane treatment after acid etching reduces microleakage at the gingival interfaces and has no influence at the occlusal margins in class V compomer-filled cavities.

Keywords: microleakage; acid etching; silane; compomer

In clinical practice, several types of tooth-colored materials (composite resins, compomers, glass ionomers and resin-modified glass ionomers) can be used for restoration of class V cavities, including erosion, abrasion or abfraction cervical lesions. For more than a decade, compomers have been used for direct crown restorations especially for class V cavities although the current formulations are also suitable for fillings in stress bearing areas. These materials have proved increased durability, esthetics and clinical performances [1,2].

No matter of their chemical composition, tooth colored restoratives including compomers, are subject to marginal leakage [3]. Microleakage can be defined as the undetectable passage of fluids, molecules, ions or bacteria at the tooth-restoration interface [4]. The lack of adhesive bond, dissolution and shrinkage on setting have been reported to be possible causes of microleakage [5,6]. Moreover, the initial marginal gaps may be enhanced or new ones may develop as a result of thermally or mechanically induced stresses [7,8]. Thermally induced stresses may lead to gap formation and, consecutively, microleakage as a result of mismatch between the coefficients of thermal expansion between the restorative and the hard dental tissues [9,10].

Marginal microleakage in class V cavities restored with compomers has been investigated by several authors [7,11-20]. The results of the above mentioned studies emphasize that, when the gingival margins are located in dentin/cementum, microleakage occurs at the interface. The purpose of this study was to investigate to what extent the use of silanes as chemical adhesion promoters influences microleakage in class V cavities restored with a compomer (Dyract Extra).

Materials and methods

In this study, 40 crack-free and noncarious erupted mandibular third molars were used. After extraction, each tooth was thoroughly scaled to remove calculus and remaining soft tissue tags, then polished with a slurry of pumice and water. Finally, the teeth were cleaned and rinsed in tap water, then stored in physiological saline solution at 4°C containing 0.1% thymol prior to use [21, 22].

A standardized class V cavity (mesio-distal width 3 mm, occluso-gingival width of 2 mm and a depth of 2 mm) was prepared on the buccal surface of each tooth using a regular grit fissure diamond bur (no. 835, ISO 806 314 108 524 018, Germany). According to Uno et al, the cavities were prepared with 90 degrees cavo-surface angle [23]. No bevels or retention locks were prepared. The preparations were parallel to the cementoenamel junction, with their occlusal half extending approximately 1 mm above the junction. All teeth were then randomly distributed into four groups of ten teeth each.

All materials (table 1) were used according to the manufacturer’s instructions. The prepared cavities were restored as follows:

Group 1 (XIII) - self etching adhesive (Xeno III) and compomer (Dyract Extra).

Group 2 (H3 P&B) - total acid etch (DeTrey Conditioner), adhesive application (Prime&Bond NT) and Dyract Extra

Group 3 (H3 SIL P&B) - total acid etch (DeTrey Conditioner), application of silane solution (Monobond S), Prime&Bond NT and Dyract Extra. The silane solution was applied in ample amounts on both enamel and dentin, left undisturbed 60 s, followed by a gentle air dry. Before the application of the adhesive, all surfaces were left moist.

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According to Ceballos et al, all specimens were then immersed for 24 h in 2% basic fuchsin with their roots pointing upwards [27]. In this position, the level of dye was 1 mm above the gingival margins of the preparations. Using this technique, dye penetration through improper insulated root areas was avoided. Following removal from the solution, the specimens were rinsed in tap water and nail varnish was removed with a dentin curette. In order to minimize dye transportation along the interfaces during the sectioning procedures, the dye-impregnated superficial layer of the fillings was removed with a pumice slurry and a rubber cap. The teeth were sectioned through the middle of the fillings with a water cooled fine grit diamond disc (no. 916F, ISO 806 900 329 514 220), following a buccolingual plane. Each disc was replaced with a new one after sectioning every fourth specimen. The sections were examined at the occlusal and gingival interfaces with an optical microscope (model FT MIC 2665) at 10X and 100X magnification by two calibrated examiners. Consensus was reached between the observers if there were differences regarding the scores.

At both interfaces the scores were chosen according to the same criteria reported in some previous studies [27, 28].

0 - no dye penetration
1 - dye penetration up to 1/2 of the cavity depth
2 - dye penetration to the full depth of the cavity wall (not including the axial wall)
3 - dye penetration along the axial wall

When microleakage scores on the two halves of the same specimen were different, the highest score was recorded because it was more clinically relevant. The statistical analysis was performed with Kruskal - Wallis and Mann - Whitney U tests.

Results and discussions

Microleakage was found in each experimental group. The distribution of dye penetration scores at both interfaces is shown in tables 2 and 4. It can be noticed that the highest leakage scores were displayed by the control group (score 3 at both interfaces in each specimen), proving the poor self-adhesion of the compomer restorative material without any conditioning procedure.

Occlusal interface

The distribution of the microleakage scores within the experimental groups is presented in table 2. Statistically significant differences were found among the groups (Kruskal-Wallis test, table 3). The Mann-Whitney U test (table 3) revealed significant differences among groups 1-2, and 2-3, respectively. No significant differences were found among groups 1-3. Specimens in group 2 showed less microleakage than in groups 1, 3 and 4. Statistically significant differences were also found among groups 1, 2

<table>
<thead>
<tr>
<th>Specimen no.</th>
<th>Group 1 (XII)</th>
<th>Group 2 (H3 P&amp;B)</th>
<th>Group 3 (H3 SIL P&amp;B)</th>
<th>Group 4 (CTRL)</th>
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Table 2
MICROLEAKAGE SCORES AT THE OCCLUSAL (ENAMEL) INTERFACE

Legend: XII - Xeno III + Dyract Extra; H3 P&B - DeTrey Conditioner + Prime&Bond NT + Dyract Extra; H3 SIL P&B - DeTrey Conditioner + silane solution (Monobond S) + Prime&Bond NT + Dyract Extra; CTRL - control group (Dyract Extra)
and 3, and the control group (4). The complete results of the statistical analysis are shown in table 3.

**Gingival interface**

A summary of the distribution of dye penetration scores at the gingival interface is shown in table 4. Statistically significant differences were found among the groups (Kruskal-Wallis test, table 5). The Mann Whitney U test revealed significant differences among groups 1-2, 1-3 and 2-3, respectively. Statistically significant differences were also found among groups 1, 2 and 3, and group 4. Group 3 specimens showed less microleakage than groups 1, 2 and 4. The complete results of the statistical analysis are shown in table 5.

**Comparison of the occlusal/gingival microleakage within each group**

The Mann-Whitney U test showed statistically significant differences in groups 2 and 3 (table 6). In group 2, less microleakage was detected at the occlusal interface, while in group 3 the gingival interface exhibited less dye penetration. No statistically significant differences were found in groups 1 and 4. These results show that silane treatment significantly reduces microleakage at the dentin/cementum interface and has no influence on dye penetration at the occlusal interface.

Because microleakage at the gingival interfaces (dentin/cementum) of class V composite and compomer direct restorations nearly always occurs, the efficiency of the adhesive systems to hybridize the cementum layer must be questioned. Surprisingly, the hybridization of cementum has not been widely investigated until the mid '90s [29]. Moreover, one study reports that microleakage in the cervical area of class III and V restorations may be attributed to three main substrate characteristics: (1) the low number of dentin tubules in the outermost 200-300 μm of the gingival floor (2) the absence of tubules in the limiting 100 μm of the cervical margin and (3) the relatively high organic content of dentin [30]. The same study concluded that the bonding substrate at the gingival margins has a small contribution in establishing a micromechanical retention. Taking into account all these scientific facts, this study investigated whether the silane solution as a chemical adhesion promoter influences microleakage in class V compomer - restored cavities.

For this purpose, the in vitro microleakage testing was chosen. This method is widely applied due to its ease of application and low cost [31]. The main disadvantage is the poor standardization of the method. Thus, the comparison of the results from different studies is critical [32].

Some previous studies regarding microleakage in composite-restored cavities reported no detectable microleakage at enamel margins [33, 34]. In this study microleakage occurred at enamel margins but at a less extent than at the dentin/cementum interface. Similar results were reported by other investigators [8, 35, 36]. The overall conclusion that can be drawn from these studies is that in class V cavities with margins in enamel and dentin/cementum, restored with composite materials, microleakage occurs at a higher rate at the gingival interface.

In the last decades, several attempts to obtain chemical adhesion to dentin have been made. One of the first attempts is attributed to Buonocore et al [37], who used an acidic monomer (glycerophosphoric acid dimetacrilate). Other authors used polyurethanes which bond with the hydroxyl, amino or carboxyl groups of tooth proteins. Acid etching and/or silane pretreatment, improved the adhesion of polyurethanes to both dentin and enamel substrates. Another monomer was developed by Bowen who synthesized N-phenylglycine glycidyl methacrylate (NPG-GMA) which developed chemical
bonds with dentinal calcium [38]. Other methods used halophosphorous esters of unfilled resins such as bisphenol A-glycidyl methacrylate (Bis-GMA) or hydroxyethyl methacrylate (HEMA) whose bonding mechanism is based on ionic interactions between the phosphate groups and dentinal calcium [39]. All these initial dentin bonding agents had poor clinical results. Current formulations of some available adhesives are based on 4-methacryloxyethyl-trimellitic anhydride (4-META), which develops chemical bonds with the tooth substrate [40].

In this study, the role of silane application in reducing microleakage at the dentin/cementum interface might be explained by its ability to produce chemical bonds with the substrate. This supplementary bond might enhance the micromechanical one (if it exists) since some previous studies reported that the hybrid layer is not so important for the mechanism of adhesion [41, 42]. The results of this study show that silane application does not reduce microleakage at enamel margins. This might be explained by the fact that the formation of chemical bonds is mainly by the formation of chemical bonds which is less in enamel than in dentin, but this supposition needs further investigation. Ongoing studies must investigate (1) the chemical mechanism of silane bonding to dentin (2) the ultramorphology of the adhesive/dentin interface and (3) the effects of silane solution on the pulp. Also, studies must focus on the effect of higher concentrations of silane on microleakage.

Conclusion

Within the limitations of this study, the following conclusions can be drawn:
- The silane treatment of the acid conditioned enamel margins has no statistically significant influence in reducing microleakage;
- The additional silane treatment of previously acid etched dentin, significantly reduces microleakage at the gingival interface.

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References


Table 6

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<tr>
<th>Group</th>
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♦ statistically not significant ♦ statistically significant.

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