Microleakage in conservative cavities varying the preparation method and surface treatment

Juliana Abdallah ATOUI1, Michelle Alexandra CHINELATTI2, Regina Guenka PALMA-DIBB2, Silmara Aparecida Milori CORONA3

1- DDS, MSc, Department of Restorative Dentistry, Ribeirão Preto Dental School, University of São Paulo, Ribeirão Preto, SP, Brazil.
2- DDS, MSc, PhD, Department of Restorative Dentistry, Ribeirão Preto Dental School, University of São Paulo, Ribeirão Preto, SP, Brazil.
3- DDS, MS, PhD, Associate Professor, Department of Restorative Dentistry, Ribeirão Preto Dental School, University of São Paulo, Ribeirão Preto, SP, Brazil.

Corresponding address: Silmara A. M. Corona - Faculdade de Odontologia de Ribeirão Preto - USP - Departamento de Odontologia Restauradora - Avenida do Café, s/nº, Monte Alegre - 14040-904 - Ribeirão Preto, SP - Brazil - Phone: +55-16-3602-4075 - Fax: +55-16-3602-4781 - e-mail: silmaracorona@uol.com.br, michinelatti@hotmail.com

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ABSTRACT

Objective: To assess microleakage in conservative class V cavities prepared with aluminum-oxide air abrasion or turbine and restored with self-etching or etch-and-rinse adhesive systems. Materials and Methods: Forty premolars were randomly assigned to 4 groups (I and II: air abrasion; III and IV: turbine) and class V cavities were prepared on the buccal surfaces. Conditioning approaches were: groups I/III - 37% phosphoric acid; groups II/IV - self-priming etchant (Tyrian-SPE). Cavities were restored with One Step Plus/Filtek Z250. After finishing, specimens were thermocycled, immersed in 50% silver nitrate, and serially sectioned. Microleakage at the occlusal and cervical interfaces was measured in mm and calculated by a software. Data were subjected to ANOVA and Tukey’s test (α=0.05). Results: Marginal seal provided by air abrasion was similar to high-speed handpiece, except for group I. There was SIGNIFICANT difference between enamel and dentin/cementum margins for to group I and II: air abrasion. The etch-and-rinse adhesive system promoted a better marginal seal. At enamel and dentin/cementum margins, the highest microleakage values were found in cavities treated with the self-etching adhesive system. At dentin/cementum margins, high-speed handpiece preparations associated with etch-and-rinse system provided the least dye penetration. Conclusion: Marginal seal of cavities prepared with aluminum-oxide air abrasion was different from that of conventionally prepared cavities, and the etch-and-rinse system promoted higher marginal seal at both enamel and dentin margins.

Key words: Dental air abrasion. Dental cavity preparation. Marginal adaptation. Dental etching.
However, these systems produce a deep demineralized area, without the certainty of complete infiltration of monomers into the exposed collagen fiber mesh, thus affecting the longevity of adhesion.

Self-etching adhesives use non-rinse acidic monomers that simultaneously condition and prime dentin, eliminating the acid-conditioning step and reducing the technique sensitivity. This technique avoids the formation of extensive demineralized areas, which may not be fully impregnated by monomers. According to the literature, the incorporation of smear layer to the adhesive interface can result in a more defective adhesion area.

The most cited reasons for failure of adhesive restorations placed with earlier adhesives are loss of retention and marginal adaptation. The behavior of restorative materials in cavities prepared with aluminum oxide air abrasion has been extensively investigated, and, in general, differences have not been observed between the restorations of cavities prepared with air abrasion or turbine followed by acid conditioning. The restorations that did not receive acid conditioning after preparation with air abrasion presented increased microleakage. In addition, better marginal seal has also been observed in enamel margins of cavities prepared with air abrasion.

Despite the advances in restorative dentistry, there is only a limited number of studies reporting the effectiveness of self-etching adhesive systems in the sealing ability of cavities prepared with air abrasion. Thus, the present study evaluated in vitro the degree of microleakage in conservative cavities prepared with air abrasion and restored using a self-etching adhesive system. The hypothesis of this study was that conservative class V cavities prepared with air abrasion and restored with a self-etching primer have less marginal microleakage.

MATERIAL AND METHODS

The research protocol was approved by the Research Ethics Committee of Ribeirão Preto Dental School, University of São Paulo (process # 2003.1.312.58.9).

Forty sound human premolars, extracted within a 6-month period and stored in 0.9% saline solution at 4°C, were examined to confirm the absence of defects in enamel and dentin, and selected for the study. Teeth were carefully cleaned with a hand scaler and water-pumice slurry in prophylaxis rubber cups, and randomly assigned to 4 groups (n=10), according to the cavity preparation method and conditioning approach. The experimental groups were as follows: Group I: Air abrasion + Phosphoric acid; Group II: Air abrasion + Self-priming etchant; Group III: Turbine + Phosphoric acid; Group IV: Turbine + Self-priming etchant.

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a visible light-curing unit with a 450 mW/cm² output (XL 3000, 3M ESPE, St Paul, MN, USA). The cavities were restored with a hybrid light-activated composite resin (Z250, 3M; shade A3.5), inserted in three increments (maximum thickness of 2 mm). The first two increments were applied obliquely against the occlusal and the gingival walls, respectively. The final increment was inserted following tooth contouring. Each increment was light-cured for 40 s with the same visible light-curing unit.

Specimens were stored for 24 h in distilled water at 37°C and then the restorations were polished with Super-Snap disks (Shofu Inc., Kyoto, Japan) in a decreasing abrasive order. All cavity preparations, restorations and finishing procedures were performed by the same operator.

The specimens were subjected to a thermocycling regimen of 500 cycles between 5°C and 55°C waterbaths. Dwell time was 1 min, with a 3-s transfer time between baths. In preparation for the dye penetration test, the teeth were dried superficially, had the apices sealed off with epoxy resin and the entire tooth received two coats of nail varnish, except for a 2-mm window around restoration margins. As the nail varnish dried, the teeth were immersed in distilled water for 2 h, and then immersed in a 50% aqueous silver nitrate solution for 8 h, kept in a light-proof container. Next, the teeth were rinsed thoroughly in tap water and the nail varnish was entirely removed with a sharp instrument.

The specimens were embedded in chemically activated acrylic resin (Jet, Clássico, São Paulo, SP, Brazil) and sectioned longitudinally in a mesiodistal direction with a water-cooled diamond saw, in a sectioning machine (Minitom; Struers A/S, Copenhagen, Denmark). Then, they were embedded again in acrylic resin blocks and sectioned in a buccolingual direction, providing two to three 1.0-mm-thick sections for each tooth. Then, the sections were exposed to the light of a photoflood lamp for 20 min (115 V, 500 W) to reveal the silver nitrate, which, exposed to light, acquires a dark color, allowing the visualization of the tracer-penetrated areas. The sections were initially thinned in a polishing machine (Struers A/S) with 180- to 600-grit silicon carbide paper, and then manually smoothed with 1000- to 1200-grit SiC paper to obtain a flat surface and a final thickness of approximately 0.25 mm.

The cuts were identified and carefully fixed on microscopic slides, and the margins were analyzed separately; each margin was viewed under a x5 magnification optical microscope (Axiostar Plus, Carl Zeiss Vision GmbH, München-Hallbergmoos, Germany) connected to a digital camera (Cyber-shot 3.3 MPEG Movie EX, model no. DSC-S75, Sony Corporation, Tokyo, Japan). The images obtained were transmitted to a personal computer and, after digitization, they were analyzed by Axion Vision 3.1 software (Carl Zeiss Vision GmbH), which performs a standardized assessment of the tracer’s extent along the tooth-composite-interface and allows a quantitative measurement in millimeters. The dye penetration depth along the cavity wall (including both occlusal and cervical margins) of each cut was measured. Microleakage at each interface was obtained by calculating the ratio (percent value) of the tracer penetration along the tooth-restoration interface and the total length of the enamel and/or dentin interface. Tracer penetration at enamel and dentin interfaces was calculated separately for each section, and then the mean for each tooth was determined.

Data were analyzed statistically by three-way ANOVA followed by Tukey’s test for pair-wise multiple comparisons at a 0.05 significance level.

RESULTS

The means of dye penetration and standard deviations at both interfaces for each experimental group are shown in Table 1.

Three-way ANOVA revealed statistically significant differences (p<0.05) for the margin types and conditioning approaches (p<0.05), and that the margin in enamel and total-etching system had significantly lower microleakage.

Analyzing the interaction of factors, the etch-and-rinse system showed statistically significant difference (p<0.05) between enamel and dentin/cement margins in the air-abraded cavities, but not in the bur-prepared cavities. Groups II (air abrasion + Tyrian SPE) and IV (turbine + Tyrian SPE) showed
higher microleakage degrees on both margins and different significantly from groups I and III.

**DISCUSSION**

The findings of this work showed that air abrasion technique for cavity preparations provided different seal at the margins of composite resin restorations compared the turbine. This fact may be due to the macro and microscopic irregularities in the abraded surface, which may have influenced in the mechanical interlocking. Moreover, the roughened surface resulting from air abrasion preparation limits the penetration of the adhesive agent when this modified surface is not etched with acid. In addition to these factors, the permanence of aluminum oxide particles on the abraded surface can also influence the penetration of the adhesive. A scanning electronic microscopy study revealed that the morphology of the adhesive interfaces of the lateral walls of air-abraded cavities was similar to the obtained with bur-prepared. However, the adhesive interfaces of the pulpal walls were more irregular in the air abrasion preparations. Several studies have found a decrease in marginal seal in cavities prepared with air abrasion, mainly when 27-µm-diameter particles were used. Another important aspect to be observed in the present study is that the absence of finishing in cavities prepared with air abrasion probably no interferes in the adaptation of the restorative material. Corona, et al. verified that air abrasion preparation do not promote a well define contour in cavity margins and walls that can adversely influence in the marginal seal of the restorations.

In the present work, differences were observed between enamel and dentin/cementum margins, only for phosphoric acid. This could be ascribed to morphological and structural differences of the substrates, as well as their distinct composition. Such results corroborate the findings of the literature which report better behavior of enamel surface as for adhesive resistance as for marginal microleakage.

Another important aspect that must be taken into account is the polymerization shrinkage of the resinous restorative material. Despite conservative preparations and the incremental composite insertion technique, as performed in this study, thereby reducing the amount of material and the polymerization shrinkage, it was not possible the completely seal both cavity margins. It is known that the resultant stress of polymerization shrinkage of composite resin can generate tensions between the restorative material and tooth substrate, which, consequently, can generate gaps in the adhesive interface. This stress depends on some factors, such as the cavity configuration (factor C), and can reach around 10 to 15 MPa. In spite of the care with regard to this factor, Class V restorations present a relatively small factor C that results in less stress in the adhesive interface, creating less gaps and subsequent less microleakage.

In the overall and independent analysis of the studied factors, the surface treatment with the etch-and-rinse system provided better marginal seal than the self-etching system. This fact may be explained by the surface morphological pattern created after phosphoric acid application. At enamel, this acid promotes a demineralization, which produces an intra- and interprismatic dissolution that results in irregularities, through which the adhesive agent can flow and form a micromechanical interaction due to the formation of resinous tags after its polymerization. At dentin, this acid completely removes the smear layer, demineralizing the peri- and intertubular dentin, widening dentinal tubule openings and increasing the permeability of this substrate.

According to Hannig, et al. (2004), tooth surface treatment with self-etching agents does not remove the smear layer significantly, since it is not carried through the washing of the surface, remaining some regions without treatment. In addition, self-etching systems consist of weak acids The reactive components in the primers of these systems consist of phosphates derived from hydrophilic monomers that are able to treat and penetrate simultaneously in the enamel surface, but not in a homogeneous way.

In this study, for both preparation methods, enamel margins showed higher microleakage values when the self-etching system was applied. A feasible explanation for such behavior is the lower capacity of these systems to etch as 35% or 37% phosphoric acid, due to the relatively higher pH of these self-etching agents (1.5 - 3.0) as compared to phosphoric acid (pH 0.02 – 0.42). In dentin, it is known that a conditioning agent with low pH, as phosphoric acid, provides more demineralization.

| Preparation method | Margins       | Phosphoric acid | Self-priming etchant |
|--------------------|---------------|-----------------|----------------------|
| Air abrasion       | Enamel        | 6.07 (7.57) a A | 34.45 (15.36) b A    |
| Dentin/cementum    | 31.70 (15.52) aC| 54.54 (30.06) b A|                      |
| Turbine            | Enamel        | 15.04 (9.33) a AB| 32.91 (9.90) b A     |
| Dentin/cementum    | 18.53 (12.32) a BC| 42.75 (21.10) b A|                      |

Table 1- Mean values and standard deviations of microleakage for enamel- and dentin/cementum-composite-interface according to the preparation method and surface treatment.
At dentin/cementum margins, this study disclosed that the conventional preparation with turbine, associate to the etch-and-rinse system, still could not be replaced by air abrasion preparation. The particle stream acts indiscriminately in the organic and inorganic portions of the substrate, leading to surface roughness and tubule obliteration, and consequently absence of resinous tags, compromising the adhesive layer and the marginal seal\(^2,15\).

The findings of this study revealed a distinct behavior of the adhesive systems, and showed that the aluminium oxide air abrasion did not influence significantly the marginal seal of conservative class V restorations, with improved results in enamel after acid etching. It is important to emphasize that, clinically, no matter its length, the presence of significant leakage is the problem. Also, the intrinsic aspects related to adhesive systems, such as the pretreatment technique required, composition and mechanism of adhesion, may decisively influence their effectiveness in sealing cavity margins and preventing marginal microleakage.

Comparison with the literature is difficult due to the lack of studies assessing the factors studied in this work. Thus, further studies are necessary to investigate the properties of restorative materials as well as other aspects of cavity preparation and tooth conditioning.

CONCLUSIONS

Based on the results obtained in this study, it may be concluded that: conditioning of enamel and dentin with phosphoric acid provided better marginal seal than the self-etching approach; marginal seal of class V cavities prepared with air abrasion was different from that of conventional turbine preparation; there was higher marginal seal of enamel margins than dentin/cementum margins for groups I and III.

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