

## Effect of the Number of Coats of Simplified Adhesive Systems on Microleakage of Dentin-Bordered Composite Restorations

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### Abstract

**Aim:** This study tested the null hypothesis that there is no difference on microleakage of dentin-bordered composite restorations using single or double coats of adhesive from one-bottle adhesive systems.

**Methods and Materials:** The enamel surface was removed from freshly extracted bovine teeth, and standardized Class V cavities (3 x 3 x 1.5 mm) were made at the cervical areas of buccal surfaces. Teeth were restored and grouped according to type of adhesive systems [Prime Bond 2.1 (PB2.1), Prime & Bond NT (PBNT), and Single Bond (SB)] and to the number of coats (one or two) to be used. The restorations were polished and immersed in a 0.5% aqueous solution of basic fuchsin for four hours. Teeth were then sectioned and the most infiltrated section of each tooth was selected under magnification, scanned, and quantitatively analyzed using a computer program. Data were analyzed using two-way analysis of variance (ANOVA) and Student-Newman-Keuls ( $\alpha=0.05$ ).

**Results:** Groups without filler content (PB2.1 and SB) showed no difference in microleakage using single or double coats. However, PBNT (with nanofiller) showed statistically less microleakage when only one coat was applied. The influence of the number of coats of the adhesive systems on dentin margin microleakage was material dependent.

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**Conclusion:** All adhesive systems demonstrated microleakage, however, it could be minimized using two coats of non-filled or one coat of a filled adhesive system.

**Keywords:** Adhesive system, adhesive layer, nanofiller, microleakage, dentin, adhesion, resin composite

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## Introduction

A variety of adhesive systems are available to restore teeth affected by caries and non-carious dental lesions.<sup>1,2</sup> The success of the first generation of bonding systems was due to its application only on enamel because it is a homogeneous substrate.<sup>3</sup> Dentin substrate is more complex than enamel, and the clinical employment of these bonding systems still is a major challenge.<sup>2,4,5</sup> The comprehension of dentin as a dynamic substrate component of the dentinopulpal complex was essential to improve dentin bonding agents. Such improvements must take into consideration substrate properties in order to establish hybrid layer formation.<sup>6</sup>

One-bottle adhesive systems were introduced to properly use an adhesive system on both enamel and dentin and to reduce working time. Its popularity is primarily due to the reduced clinical steps necessary to achieve satisfactory bonding resistance.<sup>1,2,6,7</sup> However, many drawbacks still remain when these systems are subjected to actual clinical use. These include marginal staining, postoperative sensitivity, and the lack of complete margin sealing.<sup>1,2,5</sup> This is partially due to the stress generated at the interface resulting from the established competition of forces between the stress of shrinkage of polymerization from resin composite and the adhesion forces to the dental substrate.<sup>8</sup>

In order to minimize this limitation, filled bonding systems were developed. The use of fillers has shown to render release of such stresses and can be incorporated as an important ingredient for this purpose.<sup>1,7,9,10</sup> Another strategy to enhance bonding resistance was to apply more coats of adhesive in an attempt to guarantee a more uniform adhesive coat.<sup>7</sup> This is also related to the capacity of the adhesive thickness to absorb resin composite shrinkage stress.<sup>10,11</sup>

The aim of this study was to test the null hypothesis there is no difference between one and two coat applications on microleakage of dentin margins of composite restorations regardless of the adhesive system used.

## Methods and Materials

This study was approved by the Ethical Committee of Bauru Dental School at São Paulo University in Bauru, São Paulo, Brazil.

Sixty extracted bovine incisor teeth were selected and stored in 0.1% thymol solution. Cervical enamel buccal surfaces were removed to expose flat dentin surfaces using SiC abrasive paper in a polishing machine under running water. Class V cavities (3 x 3 x 1.5 mm) at 2 mm above cemento-enamel junction were prepared using a high-speed piece and a #245 carbide bur. Dimensions were checked using a digital caliper (Digimatic Caliper, 500-144B, Mitutoyo Sul Americana Ltda., Suzano, SP, Brazil) and a periodontal probe. Cavities were finished using hand instruments to obtain internal round angles, a flat axial wall, and no beveled cavosurface margins.

Teeth were randomly divided into six groups according to the restorative treatment and materials as follows:

**Group 1:** After 37% phosphoric acid gel treatment for 15s, the dentin was washed and gently dried. Prime & Bond 2.1 (PB2.1) (Dentsply Ind. e Com. Ltda, Petrópolis, RJ, Brazil) was applied to the substrate; after 30s, solvent evaporation was promoted by gentle air-drying for 5s and light cured for 10s. Another coat of PB2.1 was applied, dried, and light cured. A curing unit (3M Curing Light XL 1500, 3M Dental model 5518AA, Canada) with 500mW/cm<sup>2</sup> power density

was used for light-curing while being periodically monitored with a radiometer (Curing radiometer, Model 100P/N-150503 - Demetron Research Corp., Danbury, CT, USA).

**Group 2:** Dentin etching was performed for 15s with 37% phosphoric acid gel, then washed and gently dried. Prime & Bond NT (PBNT) (Dentsply Inc. e Com. Ltda, Petrópolis, RJ, Brazil) was applied once to the substrate; after 30s, solvent evaporation was facilitated using gentle air-drying for 5s and then light-cured for 10s.

**Group 3:** A 35% phosphoric acid gel was applied for 15s to the dentin surfaces, washed away, and dried with absorbent paper and gently air-dried. Subsequently, two consecutive coats of Single Bond (SB) (3M-ESPE Dental Products, St. Paul, MN, USA) were applied to the substrate. Solvent evaporation was promoted by gentle air-drying for 5s and then after 30s light-cured for 10s.

Groups 1, 2, and 3 followed the manufacturers' instructions. Teeth restored in groups 4, 5, and 6 followed the same protocol of groups 1, 2, and 3, respectively, with an additional adhesive coat application for each bonding system.

All groups were restored with B3 Esthet X resin composite (Dentsply Ind. e Com. Ltda, Petrópolis, RJ, Brazil) in two diagonal increments then light-cured for 40s each. The restorations were stored for a week in deionized water at  $37 \pm 1^\circ\text{C}$ . Polishing and finishing procedures were conducted with Sof-lex disks (3M-ESPE Dental Products, St. Paul, MN, USA).

Teeth were coated with nail varnish (Maybelline LLC, Dist., New York, NY, USA) except for a 1 mm area around the restoration. All specimens were subsequently immersed in 0.5% aqueous solution of basic fuchsin for 4h and then rinsed under running tap water for 24h. Specimens were sectioned in a mesio-distal direction with a low speed diamond saw in a sectioning machine (Isomet, Buehler Ltd, Lake Bluff, IL, USA) under a water coolant.

All obtained sections (at least three sections of 0.5 mm per tooth) were identified and examined at X100 magnification under a stereomicroscope (Axioskop-2, Zeiss, Germany). Specimens with greater level of dye penetration were chosen and

Group	Adhesive (type)	Adhesive Process Applied*
1	PB2.1 (non-filled)	1X
2	PBNT (filled)	1X
3	SB (non-filled)	1X
4	PB2.1 (non-filled)	2X
5	PBNT (filled)	2X
6	SB (non-filled)	2X

\*According to manufacturer's instructions

submitted to ImageTools software (UTHSCSA, San Antonio, TX, USA) for quantitative analysis. Data was submitted to statistical analysis using two-way analysis of variance (ANOVA) and Student-Newman-Keuls ( $\alpha = 0.05$ ).

### Results

When a no-filler content adhesive system was used, there was no difference ( $p > 0.05$ ) in the microleakage of treated groups regardless of whether one or two coats were applied. PBNT showed statistically more microleakage when a double coat was applied ( $p < 0.05$ ). For one coat groups, PB2.1 statistically yielded more microleakage than the other groups ( $p < 0.05$ ). When two coats were applied, SB provided significant less microleakage than PB2.1 and PBNT which were not different from each other ( $p > 0.05$ ). Microleakage results are shown in Table 1.

### Discussion

Satisfactory hybrid layer formation is the foundation for the success of adhesive restorations, since it is the structure that forms the bond between composite resin and dentin and "seals" the underlying dentin. Failures in the tooth/restoration interface result in microleakage, postoperative pain, tooth fracture, and secondary caries.<sup>12,13</sup> Reduction of operator steps in the new one-bottle adhesive systems relies on a major composition complex

**Table 1. Marginal leakage and standard deviation of tested groups.**

Group	Single coat (mm ± sd) (n)	Double coat (mm ± sd) (n)
SB	0.81 ± 0.35 (10) <sup>Aa</sup>	0.73 ± 0.53 (10) <sup>Aa</sup>
PB2.1	1.78 ± 0.76 (9) <sup>Ba</sup>	1.36 ± 0.61 (10) <sup>Ba</sup>
PBNT	0.96 ± 0.25 (10) <sup>Aa</sup>	1.49 ± 0.62 (9) <sup>Bb</sup>

Same lowercase letters indicate no statistical differences in the same line ( $p < 0.05$ )  
 Same uppercase letters indicate no statistical differences in the same column ( $p < 0.05$ )

(acidic and hydrophilic monomers, solvents, and nanofillers) which may influence the final success of the restorations.<sup>1,2,14,15</sup> In addition, polymerization shrinkage acts as a limitation of the dental composites and may contribute to marginal failures.<sup>12,13</sup>

The results of the present study indicate even though no significant differences were found there is a trend for less microleakage when SB and PB2.1 were applied twice despite manufacturers' instructions. Double coats were previously recommended by some authors in order to obtain a more homogeneous layer especially for simplified systems.<sup>7,16</sup>

On the other hand, different results were detected when, with filler content, was used. Some authors<sup>17</sup> suggested filler may reduce adhesive penetration into etched dentin producing a defective hybrid layer. The filler may be found to be congested around dentin tubular orifices but not within interfibrillar spaces.<sup>18</sup> However, in the present work this phenomenon should negatively influence adhesion and facilitate microleakage on the PBNT first coat application group but it affected only the second coat group. In this case it seems the presence of fillers possibly congesting the tubular orifices does not directly correlate to microleakage.

It is expected filled bonding agents absorb shock from the polymerization process.<sup>12</sup> This rationale is similar to applying flowable resin composites under a resin composite of higher modulus of elasticity.<sup>19</sup>

Montes et al.<sup>9</sup> noted the hybrid layer, having a relatively low elastic modulus, may not be considered to serve as a stress absorber due to its limited thickness, while the adjacent adhesive layer shows a distinct behavior. Choi

et al.<sup>11</sup> observed contraction stress decreased significantly as adhesive thickness was increased using a three-step system where a hydrophobic resin bond was separately applied. In an other study, Pradelle-Plasse et al.<sup>12</sup> verified that filled Optibond Solo Plus was superior to unfilled SB using a single application to minimize microleakage. On the other hand, Ausiello et al.<sup>10</sup> suggested a low elastic modulus adhesive should be applied in one coat only and that with a high modulus more coats should be applied to adequately absorb shrinkage stresses.

Perhaps another explanation for our results relates to the rigidity of the PBNT, since materials with a high elastic modulus have difficulty absorbing and relieving stresses during resin composite polymerization shrinkage.<sup>20</sup> Nevertheless, there is still a lack of information about the shrinkage and rigidity of filled adhesives.<sup>8</sup>

Koike et al.<sup>16</sup> investigated two different resin composites, Silux Plus and Z100, associated with one or two coats of SB. The authors verified less gap formation when two coats were applied instead of one. Similar results were observed by Choi et al.<sup>11</sup> that found less microleakage results using more non-filler adhesive coats. These results were attributed to a reduced stress generation from polymerization shrinkage when a thick adhesive layer is obtained. These two studies confirm our results.

Application of more coats of adhesive systems also yielded higher bonding resistance than a single application.<sup>21</sup> However, Swift et al.<sup>22</sup> and Kubo et al.<sup>23</sup> claim one can be aware of the correlation between bonding resistance and clinical microleakage occurrence because many other factors are also involved such as occlusal loading and thermal changes.<sup>9</sup>

Generally, studies<sup>7,16</sup> suggest multiple coats of adhesive systems result in a more satisfactory performance by improving the longevity of composite resin restorations. However, this is limited to the non-filler adhesive systems. Pashley et al.<sup>7</sup> recommended multiple coats of adhesive to minimize the effect of any layer not completely cured which can compromise the bond. Montes et al.<sup>9</sup> compared the morphological and tensile bond strength of an unfilled adhesive with low-viscosity composites and a filled adhesive using one and two coats. The tensile bond strength test revealed no differences among the groups. However, there was evidence of morphological differences in the layer that absorbs stress shock. Partial cohesive failure in dentin decreased which suggests a low elastic modulus layer works as a shock absorber

“stress-breaker” when low-viscosity composites are used. The same rationale was found for filled adhesive systems.

### Conclusion

Clinical trials are essential to confirm the superiority promised with filled adhesives. Swift Jr<sup>24</sup> compared the clinical performance of non-carious cervical lesions restored with unfilled and filled systems for 18-months and did not detect any benefit provided by the filled adhesive systems.

It is essential professionals be aware of correct indications and applications of adhesive systems, minimizing possible failures of restorations.

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