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RESEARCH ARTICLE

Does bonding to Dentin reduce Gap formation in Composite Restorations?

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ABSTRACT

This study evaluated the effect of adhesive application only to enamel on the gap formation of composite resin restorations performed with different adhesive systems and submitted to mechanical cycling. Standardized cylinder-shaped cavities were prepared on the buccal surface of 60 bovine incisors. Two etch-and-rinse [Adper Scotchbond Multi-purpose (3M ESPE, St. Paul, MN, USA) and Adper Single Bond 2 (3M ESPE)] and one self-etching [Clearfil SE Bond (Kuraray, Osaka, Japan)] adhesive systems were evaluated. The adhesives were applied only to enamel or to both dentin and enamel. After adhesive light activation, the cavities were restored with composite resin. The restorations were finished and polished; the marginal adaptation was analyzed using scanning electronic microscopy (SEM, 500× magnification) in low-vacuum mode. After the first evaluation, the samples were submitted to mechanical cycling (300,000 cycles of 80 kN and 1.5 Hz) and a new evaluation was performed. There was observed any gap for all experimental conditions before and after mechanical cycling. Bonding to dentin does not alter the marginal adaptation of composite restorations.

Keywords: Adhesives, Composite resins, Dental bonding, Dental restoration failure.

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INTRODUCTION

Despite the improvements of restorative material in recent decades, the marginal integrity of restoration remains a challenge for dentistry. Poor marginal adaptation may produce marginal discoloration, postoperative sensibility and secondary caries.[1] These are the most frequent reasons to replace or repair an adhesive restoration.[2] The marginal failure of composite resin restorations is mainly related the restorative technique, resin composite and adhesive system used.[3]

Debonding followed by gap formation can be observed when the restoration is submitted to stresses. If stress exceeds the bond strength between the dental substrate and the adhesive system, a contraction gap will be formed, jeopardizing the restoration's longevity.[4] The stress can be caused by polymerization shrinkage or resin composite, occlusal loads and/or alterations of temperature of oral behavior.[5,6] Moreover, the gap formation can be also affected by location of restoration margins.[7]

Most studies of adhesive systems have demonstrated that the bond of adhesive to enamel is predictable.[8,9] However, the bond procedure to dentin is more complex, resulting in more failures.[10] Clinically, keeping the margins sealed is the main factor in the clinical success of adhesive restorations.[11,12] Considering that the majority of restorations have all margins at the enamel, bonding the composite only to enamel may, theoretically, be sufficient to maintain the proper marginal seal.

Thus, the aim of this study was to evaluate the effect of adhesive application only to enamel on gap formation in cavities of class V, with a margin at the enamel, submitted to mechanical cycling. The null hypothesis was that bonding to dentin and mechanical cycling does not alters gap formation of composite restorations, presenting all margins at enamel.

MATERIALS AND METHODS

One week after extraction, sound bovine incisors were cleaned, polished and examined under a light microscope (Eclipse E 600; Nikon, Shinagawa-ku, Tokyo, Japan) in order to exclude those with cracks. Sixty teeth were selected and stored in distilled water at 5°C for less than 1 month before the restorative procedure. The buccal surface was slightly wet-ground with 1200-grit SiC abrasive paper to obtain a flat area in enamel. Afterwards, a circular-shaped class V cavity (2.0 ± 0.05 mm diameter by 2.0 mm depth) was prepared on the central part of the block using a #4054 diamond bur (KG Sorensen Ind. Com. Ltda., Barueri, SP, Brazil). The cavities were performed to 4 mm from enamel-cement junction using a water-cooled high-speed turbine attached to a standard cavity preparation device. A new bur was used for each of the five preparations.

Cavities were randomly assigned into six groups according to a combination of the adhesive system and application mode. The adhesive systems used in this study and respective application descriptions are summarized in Table 1. The application was performed only to enamel or to all cavity walls (both enamel and dentin). When the adhesive was applied only to enamel, all adhesive procedures was performed under an optical microscope (30×, EMZ-TR, Meiji Techno Co., Saitama, Japan) and using an extrafine microbrush (Cavibrush, FGM, Joinville, SC, Brazil).

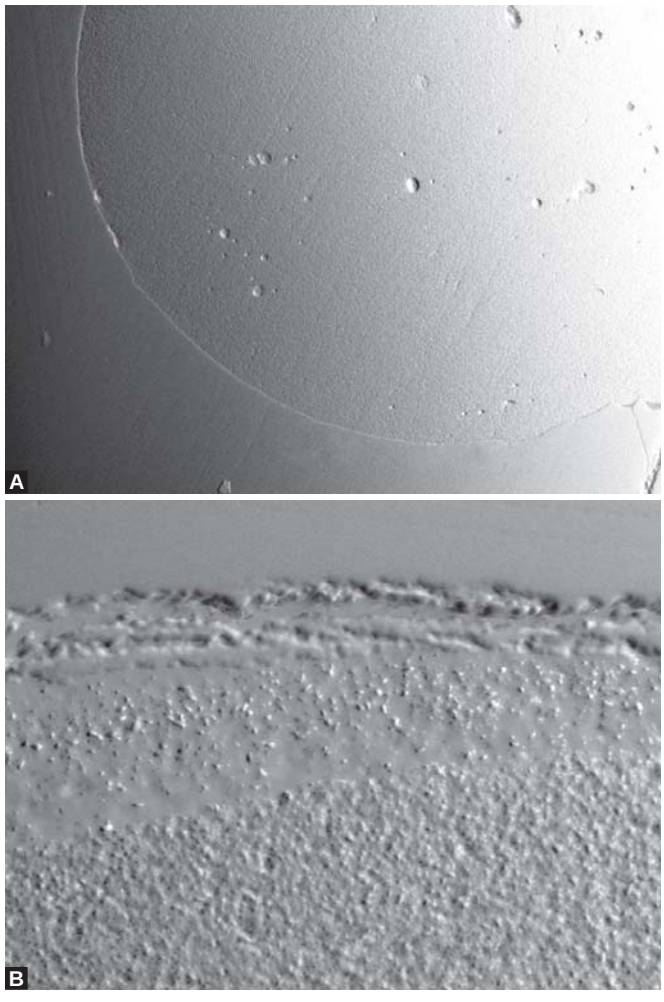
Table 1: Classification and adhesive procedure of adhesive systems used in this study

Adhesive systems	*Category*	*Adhesive procedure**
Adper Scotchbond Multipurpose (3M ESPE)	3-step etch-and-rinse	1. Acid etching (15 seconds), rinsing (15 seconds) and air drying (10 seconds) leaving dentin moist. 2. Primer and air stream (10 seconds). 3. Adhesive and light activation (10 seconds).
Adper Single Bond 2 (3M ESPE)	2-step etch-and-rinse	1. Acid etching (15 seconds), rinsing (15 seconds) and air drying (10 seconds) leaving dentin moist. 2. Two consecutive coats of adhesive, air stream (10 seconds) and light activation (10 seconds).
Clearfil SE Bond (Kuraray)	2-step self-etching	1. Primer with slight agitation (20 seconds) and air stream (10 seconds). 2. Adhesive and light activation (10 seconds).

*Manufacturers' instructions

The cavities were restored with a microhybrid resin composite (Filtek Z-250, 3M ESPE, St. Paul, MN, USA), filled in one (bulk) increment of 2 mm and light-activated for 20 seconds. A light-curing unit Optilux 501 (Demetron Kerr, Danbury, USA) with an output intensity of 650 mW/cm^2 was used in this study. The output of the light-curing unit was periodically checked using a handheld radiometer (Model 100, Demetron Kerr). After restoration, all specimens were stored in distilled water at 37^{o}C for 24 hours and polished with flexible aluminum oxide disks (Sof-Lex Pop-on®, 3M ESPE, St. Paul, MN, USA) under a water spray. All specimens were kept in water at 37^{o}C for 24 hours.

The specimens were allowed to desiccate in covered unsealed plastic containers for 48 hours at room temperature in a dust-free environment. This time was sufficient to allow complete drying of the specimen. Specimens were examined using a scanning electron microscopy (SEM; JSM-5600LV, JEOL, Tokyo, Japan), which is capable of both low vacuum (LV) and high vacuum (HV) operations. The analyses were performed under LV condition at 25 kV and 0.3 Torr. All extension of restoration margins were analyzed under 500× of magnification. After the first evaluation, samples were submitted to the mechanical load in a cyclic mechanical loading device (Erios Representações e Comércio Ltda, São Paulo, Brazil). Specimens were submitted to 300,000 cycles with a vertical load of 80 kN and a frequency of 1.5 Hz. The samples remained in distillated water at 37°C during the mechanical cycling. Afterwards, restorations margins were evaluated again.



Figs 1A and B: Representative microscopy of gap evaluation. (A) Low magnification image showing half of restoration (B) high magnification image used to evaluate the presence of gaps. *Note:* The absence of marginal gaps

RESULTS

No gap was observed for all experimental conditions at two moments of evaluation. Figures 1A and B illustrates the evaluations of restorations margins.

DISCUSSION

A proper margin sealing is essential to improve the longevity of resin composite restorations. Clinical evaluations of restorations are very complicated because of ethical reasons, and they are time-consuming and expensive. *In vitro* studies simulating oral conditions have been performed in order to permit estimation of restoration longevity. Class V cavities were chosen in this study because of their factor of cavity configuration that impairs the resin composite flowing during the polymerization shrinkage.[13,14] In the present study, there was no observed gap in restorations margins even after the mechanical cycling. Thus, the null hypotheses were rejected.

In composite restorations, gap formation is often related to polymerization shrinkage that causes tensile stress between the cavity wall and the restoration.[3] This stress can disrupt the bond and lead to the formation of gaps. Thus, a proper bond of an adhesive to dental tissue contributes to avoid gap formation.[15] The current study used bovine teeth as the bonding substrate to evaluate the microleakage of adhesive restorations. Reis et al[16] analyzed bond strength and enamel and dentine morphology as possible substitutes for human teeth in bonding tests. The values of bond strengths obtained with bovine and human teeth are similar for either enamel or dentine. In addition, the morphology presented by these two substrates was also similar. Thus, it is expected that the performance of adhesives would not be compromised by the use of bovine teeth and that the outcomes are expected to be similar for human teeth.

It has been demonstrated that all adhesives systems used in this study present proper bonding to both enamel and dentin.[9] The outcomes of this study showed that only the proper bonding to enamel is enough to avoid the gap formation. Additionally to fact that the bonding to enamel seals the restoration margins, the adhesive application only to enamel reduces the bonding area of restoration, resulting in lower C-factor.[17] Thus, it can expect a lower stress of polymerization on this situation, favoring the maintenance of marginal sealing.

The main aim of a dental restoration is to create an adequate seal, preventing the microleakage of contaminants contained in the oral environment. The outcomes of this study show that proper bonding to enamel seems to be sufficient to obtain marginal integrity and to avoid gap formation. The utilization of these adhesives on dentin did not alter the gap formation. However, it is important to emphasize that the restorations used in this study were submitted only to mechanical cycling. Considering that thermal cycling can also cause stress in dental restorations, further studies are necessary before definite conclusions can be made in determining whether similar findings will be found elsewhere.

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