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Microleakage of Class V Resin Composites using Various Self-etching Adhesives: An *in vitro* Study

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ABSTRACT

Background and aims: Microleakage has been identified as a significant problem with composite restorations because of interfacial gap formation which can result in tooth discoloration, recurrent caries, possible pulpal involvement and restoration replacement. Aim of this study is to evaluate the microleakage of self-etch adhesive system at the coronal and apical margins of class V resin composite restorations under stereomicroscope at 20× magnification.

Materials and methods: Class V cavities were prepared on the facial surfaces of 48 human premolars with coronal margins located in enamel and apical margins located in dentin. Teeth were divided into four groups: Group one—Xeno V; group two—G-Bond; group three—Clearfil S^3 Bond; group four—control. After application of bonding agent and restoration, the teeth were subjected to thermocycling. The teeth were then immersed in 1% aqueous solution of methylene blue dye for 24 hours and sectioned to allow the assessment of microleakage under microscope.

Results: Coronal and apical margins were scored separately using a 0-3 ordinal ranking system and the recorded values were statistically analyzed using Kruskal-Wallis, Mann- Whitney U-test and Wilcoxon signed rank test. Statistical analysis showed that there was less microleakage in Xeno V at coronal region and Clearfil S^3 Bond in apical region, overall Clearfil S^3 Bond showed less marginal permeability in both coronal and apical regions.

Conclusion: Specimens restored with the Xeno V and Clearfil S^3 Bond adhesive systems revealed reduced leakage at the coronal margin. At the apical margin, Xeno V showed greater leakage than the other groups, except the control.

Clinical significance: In class V restorations restored with composite resin, the choice of material affects the microleakage and retention of the restoration. This study theorizes that the self-etch adhesives show less microleakage in the coronal area than the apical margin.

Keywords: Microleakage, Class V resin composites, Self-etching adhesives.

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INTRODUCTION

Till date seven generations of bonding agents have evolved to meet the requirement of attaining good bond to both enamel and dentin.[1] Adper Prompt L-Pop is an aggressive self-etch adhesive while—Clearfil S^3 Bond, Xeno V and G-Bond are mild/ moderate.[2]

Clearfil S^3 bond is aone bottle bonding agent with minimal technique sensitivity that provides less postoperative sensitivity, high bond strength. Xeno-V (Dentsply) give improved safety due to high tolerance toward storage conditions and shows bonding performance. G-Bond (GC-America), a seventh generation bonding system is a one bottle-one coat bonding system which does not require an etching step.

MATERIALS AND METHODS

Forty eight freshly extracted human premolar teeth were selected and teeth were examined to ensure that they were free of any fracture, carious lesions, abrasion, attrition, Intrinsic as well as extrinsic stains. The teeth were cleaned and stored in a 3% sodium hypochlorite solution. Circular-shaped class V cavity preparations were cut on the facial surface at the cementoenamel junction with coronal margins located in enamel and apical margins located in dentin using a # 56 carbide bur in a high-speed hand-piece with air-water spray. Cavity dimensions were 2.0 × 2.0 × 1.5 mm (depth) measured with a periodontal probe to maintain uniformity. Then, the teeth were randomly divided into four groups (12 teeth each) according to the bonding agent used as follows:

Group 1: Xeno V

Using a microbrush applicator, Xeno-V was applied sufficiently wetting all the cavity surfaces uniformly (enamel and dentin) and excess solvent was removed by gently drying the surfaces with air syringe for at least 5 seconds. Xeno V was light polymerized for 10 seconds followed by insertion (1 increment) of the composite restoration of Gradia Direct X A2.

Group 2: G-Bond

Using a microbrush applicator, G-Bond was applied to the prepared enamel and dentin surfaces. Left undisturbed for 5 to 10 seconds and then dried thoroughly for 10 seconds with oil free air under maximum air pressure. The final result was a thin, rough, adhesive film with the frosted appearance, followed by insertion of Gradia Direct X A2 composite.

Group 3: Clearfil S^3 Bond

Using a microbrush applicator, Clearfil S^3 Bond was applied to the prepared enamel and dentin surfaces and left it in place for 20 seconds. After conditioning the tooth surfaces for 20 seconds, entire adherent surfaces was dried sufficiently by blowing high-pressure air for more than 5 seconds while spreading the bond layer thinly. The bonding agent was light cured for 10 seconds with a dental curing light, followed by insertion of Gradia Direct X A2 composite.

Group 4: Control

No adhesive agent was used in this group and cavities were directly restored with Gradia Direct X A2 composite.

All restorations were polymerized with conventional halogen light. The composites were polished with Sof-Lex flexible disks of decreasing abrasiveness. The teeth were stored in distilled water at room temperature for 7 days prior to leakage assessment.

ASSESSMENT OF MICROLEAKAGE

The teeth were thermocycled 500 times in separate water baths of 5°C and 55°C, with a dwell time of 60 seconds in each bath and a transfer time of 3 seconds. The root apices were sealed with utility wax, and the entire tooth surface was coated with two layers of commercial nail varnish to within 1.0 mm of the restoration. The teeth were immersed in a 1% aqueous solution of methylene blue dye for 24 hours at room temperature. After 24 hours, teeth were thoroughly rinsed to remove excess dye, then were invested in clear autopolymerizing resin and labeled. A low-speed diamond disk cooled with water was used to section the tooth block longitudinally through the center of the restoration from the facial to the lingual surface. Two sections were obtained from each block (24 sections per group). All the sections (Fig. 1) were subsequently examined using 20X stereomicroscope to evaluate the degree of microleakage around the restorations.

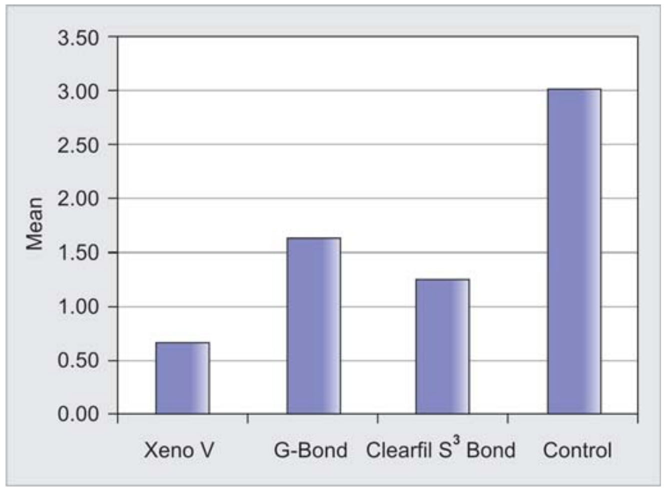
Fig. 1: Specimens after thermocycling and dye penetration

The degree of leakage was determined based on an ordinal ranking system (0-3) as follows:[5]

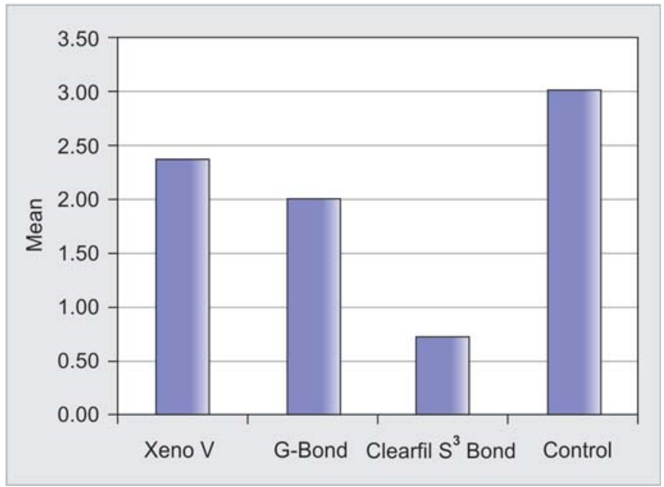
0 degree: No leakage
1 degree: Leakage up to one-half the length of the cavity wall
2 degree: Leakage along the full length of the cavity wall, not including the axial surface
3 degree: Leakage along the full length of the cavity wall, including the axial surface.

RESULTS

The experimental data were subjected to statistical analysis using Kruskal-Wallis, Mann-Whitney U-test and Wilcoxon signed rank test at a significance level of $p < 0.05$. Specimens in group 1 (Xeno V) showed less leakage at the coronal region (mean leakage 0.67) which was statistically highly significant when compared to other groups. Specimens in group 3 (Clearfil S^3 Bond) exhibited significantly less leakage than other adhesive and control group at apical margins (Table 1). Group 2 specimens (G-Bond) showed comparatively more microleakage than the other adhesive groups, but less leakage than group 4. The mean leakage of all the group specimens in the coronal region and apical region is represented in Graphs 1 and 2 respectively.



Graph 1: Mean leakage of the group specimens at the coronal margins



Graph 2: Mean leakage of the group specimens at the apical margins

DISCUSSION

The primary objective of a dental restoration is to create a 'perfect' seal, and prevent leakage of contaminants contained in the oral environment. However, long-term microleakage occurs with all restorations. Microleakage has been identified as a significant problem with composite restorations because of interfacial gap formation which can result in tooth discoloration, recurrent caries, possible pulpal involvement and restoration replacement.[5]

There are three possible routes of microleakage (1) within or via the smear layer (2) between the smear layer and the cavity varnish/cement and (3) the cavity varnish/cement and the restoration.[3] Therefore, microleakage studies provide adequate screening methods, to determine the clinical success and longevity of the adhesive systems.

Current dentin bonding systems are generally grouped into categories in terms of how they interact with the dentin smear layer. The latest development in dentin adhesion is based on simplification and reduced application time. Self-etching adhesives do not require a separate acid-etch-step as they condition and prime enamel and dentin simultaneously by infiltrating and partially dissolving the smear layer and hydroxyapatite to generate hybrid zone, which plays a major role in adhesion.[4] Hence, in the present study three self-etching adhesives: Xeno V, Clearfil S^3 Bond and G-Bond were tested for microleakage with Gradia Direct Composite.

Specimens restored with the Xeno V and Clearfil S^3 Bond adhesive systems revealed significantly reduced leakage at the coronal margin compared to the other

Table 1: Statistical analysis showing mean leakage of experimental groups at coronal and apical margins

	Coronal	*Apical*	*Mean difference*	*p*-value*	*Significance*
Xeno V	0.67	2.38	1.71	<0.001	HS
G-Bond	1.6	2.0	0.38	<0.01	S
Clearfil S^3 Bond	1.3	0.7	0.54	<0.01	S
Control	3.0	3.0	0.00	>0.05	NS

* p < 0.05; HS: Highly significant; S: Significant; NS: Non significant

adhesives. At the apical margin, Xeno V showed significantly greater leakage than the other groups, except the control. Clearfil S^3 Bond revealed superior results at both the margin locations.

The probable explanation for the result of Clearfil S^3 Bond includes: (a) Instead of acetone, Clearfil S^3 Bond uses alcohol as the primer component solvent or drying agent which prevents total dehydration of the collagen components (b) The Clearfil S^3 Bond formulation includes a proprietary 'molecular dispersion technology', enabling a two phase liquid, hydrophilic/hydrophobic component homogenous state at the molecular level, reportedly resulting in reduction and/or loss of water droplets at the adhesive interface and, therein, a superior bond. (c) Also, the 10-methacryloyloxydecyl dihydrogen phosphate adhesive monomer molecular structure allows for decalcification and penetration into the tooth structure, creating a chemical bond to calcium.[5,6]

Xeno V showed less microleakage at the coronal margins and more at the apical margins when compared to Clearfil S^3 Bond and G-Bond. These results are in accordance with a study done by McLeod et al (2010), where they found higher shear bond strength values at the enamel margins than the apical margins for Xeno V in class V cavities.[7]

Greater leakage at coronal and apical margins was observed with G-Bond. The probable explanation for the result of G-Bond includes;

1. The interface formed with G-Bond is totally different from that of the interface formed by other two bonding materials. The surface of the dentin is decalcified only slightly and there is almost no exposure of the collagen fibers. This suggests that an extremely thin (300 nm or less) interface is formed and that in this area, functional monomers contained in the bonding material react with hydroxyapatite at the 'nano' level to form insoluble calcium.[5]
2. This adhesive also differs from the other groups by how it is used; besides the fact that it is extremely simplified, it should be dried under maximum air pressure before polymerization, thus forming a very thin layer. Theoretically, this should evaporate all remaining acetone and water. However, voids seen in the resin tags represent remnants of water in the form of droplets, which were trapped in the adhesive before polymerization.[8]

Polymerization shrinkage which is a major disadvantage of for composite restorations occurs in three dimensions during and after polymerization toward the center of the restoration, toward the curing source and toward the stronger bonded surfaces.[9] This study utilized conventional curing light for curing of composites. The recent literature shows a new method of curing mechanism to control polymerization shrinkage, which is the pulse delay technique. But a study conducted by Mattei FP et al on class V resin restorations showed no significant difference in microleakage between the conventional and pulse delay light-curing techniques at both enamel and dentin margins of class V cavities.[10]

All the groups were subjected to thermocycling regimen. The goal of thermocycling is to subject the tooth-restoration assembly to extreme temperatures, similar to those found in the oral cavity during ingestion of hot and cold foods. Rosales-Leal in an *in vitro* microleakage study investigated the sealing ability of etch and rinse and self-etching adhesives in class V cavities before and after thermocycling and observed that the thermocycling had an effect on the marginal seal of self-etching adhesives.[11]

Various techniques have been used to evaluate microleakage, such as dye penetration,[12] bacterial leakage,[13] electrochemical method,[14] fluid filtration,[15] radioisotope labeling,[16] and scanning electron microscope analysis.[17] Among these techniques, dye penetration is the most widely used method to assess microleakage because of its sensitivity, ease of use, and convenience.[18,19] Dye penetration (microleakage) was examined under a stereomicroscope at 20× magnification.[5] Stereomicroscopic examination was chosen for this study as this provides a well-magnified two-dimensional view of the surface to be examined.

CONCLUSION

Specimens restored with the Xeno V and Clearfil S^3 Bond adhesive systems revealed significantly reduced leakage at the coronal margin compared to the other adhesives. At the apical margin, Xeno V showed significantly greater leakage than the other groups, except the control. Clearfil S^3 Bond revealed superior results at both the margin locations.

CLINICAL SIGNIFICANCE

In class V restorations restored with composite resin, the choice of material affects the microleakage and retention of the restoration. This study theorizes that the self-etch adhesives show less microleakage in the coronal area than the apical margin.

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