Original Article

Leakage Testing for Different Adhesive Systems and Composites to Permanent Teeth

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ABSTRACT

Aim: To explore the microleakage of different adhesive systems and flowable composites to permanent teeth. **Subjects and Methods:** In this study, a total of 84 human premolar teeth were used. Class V cavities were prepared on the buccal surfaces. The teeth were randomly assigned to six groups of 14 teeth each as follows: The first group – etch-rinse adhesive applied and cavities filled with flowable composite, the second group – etch-rinse adhesive applied and cavities filled with bulk-fill resin composite, the third group – one-stage self-etch (SE) adhesive applied and cavities filled with flowable composite, the fourth group – one-stage SE adhesive applied and cavities filled with bulk-fill resin composite, the fifth group – two-stage SE adhesive applied and cavities filled with flowable composite, and the sixth group – two-stage SE adhesive applied and cavities filled with bulk-fill resin composite. All specimens were then stored for 24 h at 37°C in distilled water. Teeth were then thermocycled for 500 cycles between 5°C and 55°C prior to immersion in 0.5% basic fuchsin for 24 h. Two mesiodistal cuts of each tooth were photographed for leakage with a digital camera. The dye infiltrated surface for each specimen was measured and data were collected with a software program. Statistical evaluations were done by nonparametric Kruskal–Wallis test and Mann–Whitney U-test. **Results:** There were statistically significant differences in mean microleakage ratio among the groups ($P < 0.05$). The first group had shown significantly increased microleakage areas than the other four groups (third, fourth, fifth, and sixth groups) ($P < 0.05$), except for the second group ($P > 0.05$). It was also no significant different between the mean microleakage areas of group fourth and group fifth ($P > 0.05$). The sixth group had exhibited the lowest microleakage areas, and it was statistically significant ($P < 0.05$) compared to the other groups. **Conclusion:** In this study, it has been found that the use of total etch adhesive systems resulted in high leakage values.

Keywords: *Adhesives, composite, evaluation, leakage*

Introduction

Nowadays, composite resins have been frequently used to restore posterior teeth since many positive advances.[1] However, there are some problems associated with composite resins in posterior teeth, as occlusal and proximal tooth wear, unusual microleakage, change in color and sensitivity, and problem of polymerization shrinkage.[2] Microleakage occurred depending on the polymerization shrinkage is one of the most important causes of failures of composite resin restorations.[3] Microleakage may lead to postoperative sensitivity, recurrent decay, marginal discolorations, and pulp inflammation.[4-6]

Therefore, manufacturers declared several adhesives including a variety of adherence techniques. These

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methods were well documented such as the etch and rinse (ER), the self-etch (SE) adhesive systems, and the glass ionomers. While the ER adhesive systems take place in two or three clinical steps, the SE adhesive systems are realized in one or two clinical step(s).[5]

Using a composite restoration in posterior teeth is generally a time-consuming activity. The researches for quickly and simple restorative procedures have remained the efforts of simplify in modern dentistry. The time required layering procedures with customary resin composites can omitted by using bulk-fill resin composites while self-etching adhesives as "all-in-one" comprise simplification of the clinical procedure with the goal of decreasing the possibility of error during the application of total-etch adhesives.[7,8] Matched with conventional/regular resin composites, various bulk-fill types prove reduced filler substance and expanded filler capacity to provide translucency, with the outcomes of poor esthetic features, lowering physical features, shortening of light-curing time and increasing the depth of cure, and ideally increasing abrasion or surface roughness.[7,9]

Therefore, in this study, it was aimed to evaluate the microleakage of different adhesive systems and flowable composites to permanent teeth.

Subjects and Methods

A total of 84 carious free premolars extracted teeth were included in this study. All subjects provided written informed consent. Superficial debris of all teeth was utilized by a hand-scaling apparatus. Then, the teeth were stored in a balanced salt solution at 22–24°C until the onward procedures. Classical class V cavities (4 mm width, 2 mm height, and 2 mm depth) were adjusted with a high-speed handpiece with water, water-cooling at the cement–enamel junction on the buccal mucosa. Teeth were divided into six different groups, and a total of 14 teeth were included in each group. Six experimental groups were formed as follows:

1. The first group: Etch-and-rinse adhesive (Prime and Bond NT/Dentsply, Konstanz, Germany) applied and cavities filled with flowable composite (Clearfil Majesty Flow; Kuraray Noritake Dental Inc., Okayama, Japan)
2. The second group: Etch-and-rinse adhesive applied and cavities filled with bulk-fill resin composite (SureFil SDR flow; Dentsply, Konstanz, Germany)
3. The third group: One-stage SE adhesive (Clearfil S3 Bond, Kuraray) applied and cavities filled with flowable composite (Clearfil Majesty Flow; Kuraray Noritake Dental Inc., Okayama, Japan)
4. The fourth group: One-stage SE adhesive applied and cavities filled with bulk-fill resin composite
5. The fifth group: Two-stage SE adhesive (Clearfil SE Bond) applied and cavities filled with flowable composite
6. The sixth group: Two-stage SE adhesive applied and cavities filled with bulk-fill resin composite.

For the first group, the prepared cavities were engraved with 37.5% phosphoric acid (Ultra-etch, Ultradent, South Jordan, UT, USA) for 30 s in enamel and 15 s in dentin, then thoroughly soaked with water for 30 s and lightly dried with compressed air leaving the surface moist. Etch-and-rinse adhesive was utilized to the cavity and left for 20 s. The solvent was detached with air and adhesive was light-cured for 20 s. Then, the cavities were filled with flowable composite followed by polymerizing for 20 s.

For the second group, the prepared cavities were etched with 37.5% phosphoric acid (USA) for 30 s in enamel and 15 s in dentin, and then thoroughly rinsed with water for 30 s and gently dried with compressed air leaving the surface moist. Etch-and-rinse adhesive was applied to the cavity and left for 20 s. The solvent was removed with air and adhesive was light-cured for 20 s. Then, the cavities were filled with bulk-fill resin composite followed by polymerizing for 20 s.

For the third group, one-stage SE adhesive was practiced to the cavity, by brushing the adhesive over the entire surface for 20 s and then spreading the excess amounts with air and light-curing it for 10 s. Then, the cavities were filled with flowable composite (Clearfil Majesty Flow) followed by polymerizing for 20 s.

For the fourth group, one-stage SE adhesive was practiced to the cavity, by brushing the adhesive over the entire surface for 20 s and then spreading the excess amounts with air- and light-curing it for 10 s. Then, the cavities were filled with bulk-fill resin composite followed by polymerizing for 20 s.

For the fifth group, two-stage SE adhesive (Clearfil SE Bond) was practiced to the cavity, by brushing the primer (1) over the entire surface for 20 s. The solvent was removed with air and then bond (2) was applied by brushing spreading the excess amounts with air- and light-curing it for 10 s. Then, the cavities were filled with flowable composite (Clearfil Majesty Flow) followed by polymerizing for 20 s.

For the sixth group, two-stage SE adhesive was practiced to the cavity, by brushing the primer (1) into the entire surface for 20 s. The solvent was removed with air and then bond (2) was applied by brushing spreading the excess amounts with air- and light-curing it for 10 s. Then, the cavities were filled with bulk-fill resin composite followed by polymerizing for 20 s [Figure 1].

All specimens were then stored for 24 h at 37°C in distilled water. Teeth were then thermocycled for 500 cycles between 5°C and 55°C, with a dwell time of 30 s and transfer time of 5 s, in accordance with the recommendation of the International Organization for Standardization (ISO/TS 11405). The specimens were sealed with a composite resin at the root apices and all external surfaces were isolated with two layers of nail varnish, except for 1 mm around the restorations. The specimens were stored in distilled water at room temperature for 24 h before they were immersed in 0.5% basic fuchsin for 24 h and rinsed under running distilled water for 1 min.

All the specimens were longitudinally sectioned in occluso-gingivally direction at the center of each restoration by means of a diamond disc. Two mesial-distal cuts of each tooth were photographed for leakage under an Olympus SZ61 Stereomicroscope (Olympus Corporation, Japan) magnification (×40) with a digital camera (FinePix S7000, Fujifilm Co., Tokyo, Japan). The images were then transferred to a personal computer and stored in TIFF format. The dye-infiltrated surface for each specimen was measured and data were collected with Auto CAD 2000 software (Autodesk Inc., San Rafael, CA, USA).

Statistical analysis

Statistical evaluations of all data were done by nonparametric Kruskal–Wallis test and Mann–Whitney U-test. The value $P < 0.05$ was considered statistically significant. Statistical analyses were performed by the statistical package for social sciences (SPSS for Windows version 18.0, Chicago, USA) for windows software.

Results

The Kruskal–Wallis test showed no significant differences in mean filling area among these six groups statistically ($P > 0.05$). There were statistically significant differences in mean microleakage ratio among these groups ($P < 0.05$). The first group had shown significantly increased microleakage areas than the other four groups (third, fourth, fifth, and sixth groups) ($P < 0.05$), except for the second group ($P > 0.05$). There were also no significant differences between the mean microleakage areas of group fourth and group fifth ($P > 0.05$). The sixth group (Clearfil SE Bond + SureFil SDR flow) had exhibited the lowest microleakage areas, and it was found to be statistically significant ($P < 0.05$) compared to the other groups [Table 1, Figures 2 and 3].

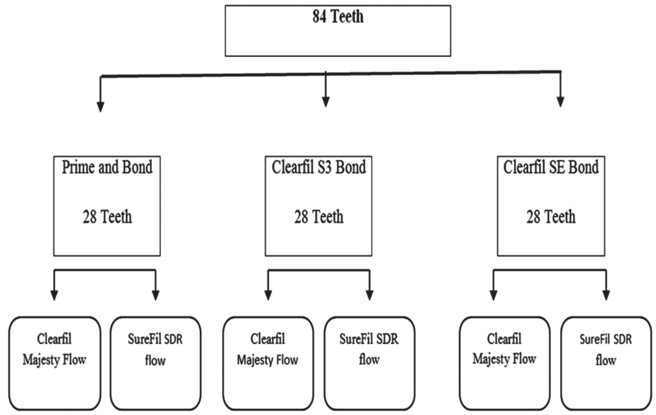

Figure 1: Flowchart of the study

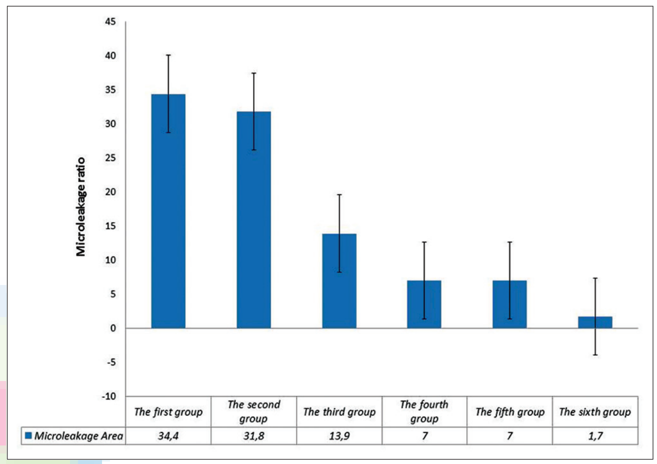

Figure 2: Evaluation of different adhesive systems and flowable composites and its effect on microleakage

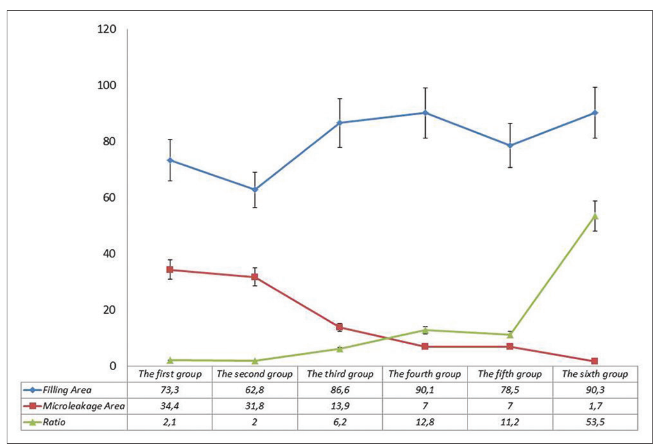

Figure 3: The ratio of the filling area to microleakage area

Discussion

One of the most challenging clinical drawbacks of the resin composite restorative materials is their marginal microleakage,[10] which occurs as a result of polymerization shrinkage, fatigue-cycling, thermal changes in the oral environment.[11] Thermocycling is

Table 1: Results of the statistical analysis; comparison of study groups according to microleakage ratio

	The first group I	The second group II	The third group III	The fourth group IV	The fifth group V	The sixth group VI
Microleakage ratio	34.4	31.8	13.9	7	7	1.7

The first group=Prime and Bond + Clearfil Majesty Flow; The second group=Prime and Bond + SureFil SDR flow; The third group=Clearfil S3 Bond + Clearfil Majesty Flow; The fourth group=Clearfil S3 Bond + SureFil SDR flow; The fifth group=Clearfil SE Bond + Clearfil Majesty Flow; The sixth group=Clearfil SE Bond + SureFil SDR Flow. *P* values: I-II=NS; I-III=0.02; I-IV=0.01; I-V=0.01; I-VI=0.001; II-III=0.03; II-IV=0.01; II-V=0.01; II-VI=0.001; III-IV=0.01; III-V=0.01; III-VI=0.001; IV-V=NS; V-VI=0.02; V-VI=0.02. NS=Nonsignificant; SE=Self-etch

such an extensively used artificial aging method. It has been defined that a thermocycling method comprising a minimum of 500 cycles in water between 5°C and 55°C is a proper artificial aging test.[12] In the current study, three adhesive systems (etch-and-rinse adhesive, one-stage SE adhesive, and two-stage SE adhesive) were used to appraise the influence of the type of bonding agent on marginal microleakage.

The bonding mechanism of these two systems is quite different.[13] The bonding mechanism of etch-and-rinse system is diffusion-based, the way of resin infiltrates into collagen fibrils and forms hybrid layer via micromechanical bonding.[14] In self-etching system, the bonding mechanism is based on the resolution of the smear layer and penetration of acidic monomers in underlying dentin which leads to the hybrid layer formation.[15] In mild self-etching adhesive systems, some hydroxyapatite remains around the collagen fibrils caused by low acidity of monomers and may have chemical reaction with functional monomer in addition to micromechanical retention which can reduce marginal microleakage.[13]

Sharafeddin *et al*., have found no statistical difference between two bonding systems (etch-and-rinse adhesive and two-stage SE adhesive) in insignificant microleakage in class II composite restorations after 6-month-storage in water.[16] Ince *et al*., also reported that total-etch adhesive system (Prime and Bond NT) was found more successful in marginal microleakage than two self-etching adhesive systems (Xeno V and G Bond).[17] However, significant differences were observed between two bonding systems (etch-and-rinse adhesive [the first and second group] and two-stage SE adhesive [the fifth and sixth group]) as for the marginal microleakage in this study design. Microleakage in the fifth group and six groups was found significantly lower than microleakage in the first and second groups. The results of this study are in accordance with those of studies which demonstrated that the use of etch-and-rinse adhesive resulted in high leakage values.[18-20]

Easier restorative procedures, such as using bulk-fill technique as a substitute for layering or the use of facilitated single-component self-etching adhesives as a substitute for multistep SE or etch-and-rinse alternatives, became more attractive for clinicians. The popularity of such simplified dental restorative treatment strategies and their clinical long-term effects have shown conflicting findings.[21] In this study, we used two different flow composite (Clearfil Majesty Flow, SureFil SDR flow). Smart dentin replacement posterior bulk fill flowable base is a fundamental component that contains fluoride, and visible light-cured roborant restorative substance. This composition comprises the following components: Barium-alumino-fluoro- borosilicate glass, strontium-alumino-fluoro-silicate glass, modified urethane dimethacrylate resin, ethoxylated bisphenol A dimethacrylate, triethylene glycol dimethacrylate, camphorquinone photoinitiator, butylated hydroxytoluene, UV stabilizer, titanium dioxide, and iron oxide pigments.[22] When comparing the differences between the composites, a study showed that microleakage area of bulk-fill had lower than Clearfil Majesty Flow without composing statistically significant differences. Trelles *et al*. observed no statistically significant difference when comparing microleakage using flowable and hybrid composites.[23] In a study conducted in 2012 by Moorthy *et al*., similar levels of the microleakage of bulk-fill (SureFil SDR and X-tra Base) and standard (GrandioSO; VOCO) composites have been reported.[24] Since all these findings indicated controversial reports, further studies are needed to evaluate the efficiency of bulk-fill composites in clinical scenarios.

Conclusion

It was found that group F (Clearfil SE Bond + SureFil SDR flow) had the lowest microleakage areas. One of the following conclusions can be drawn from this study. Use of two-stage SE adhesive systems and bulk-fill flowable composite restorations together is more admissible for microleakage.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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