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Effect of Elastic Cavity Wall and Occlusal Loading on Microleakage and Dentin Bond Strength

P Pongprueksa • W Kuphasuk • P Senawongse

Clinical Relevance

The application of filled adhesive or low viscosity resin as an elastic cavity wall had no influence on marginal leakage both at the enamel and dentin margin; however, the application had an influence on increasing the microtensile bond strength to dentin of Class V restorations. Occlusal loading significantly increased the degree of marginal leakage at the dentin margin.

SUMMARY

Objective: This study evaluated the effect of an unfilled-adhesive resin (Adper Single Bond) and a filled-adhesive resin (Adper Single Bond 2) with and without a low viscosity resin (Filtek Flow) as an elastic cavity wall on marginal leakage and dentin microtensile bond strength in Class V composite restorations under unloaded and loaded conditions.

Methods: V-shaped cavities were prepared on the buccal surfaces of 56 premolars lined with unfilled (Groups 1 and 3) or filled (Groups 2 and 4) adhesives with (Groups 3 and 4) and without (Groups 1 and 2) a low viscosity resin and restored with a resin composite. The restored teeth in each group were divided into two subgroups for unloaded and loaded conditions with 50N loading force for 250,000 cycles parallel to the long-axis of the tooth. Five specimens from each group were cut bucco-lingually 0.7 mm thick and subjected to a dye leakage test for four hours using 2% methylene blue dye. The tested specimens were then trimmed into dumbbell shapes at the gingival margin and subjected to microtensile testing. The remaining two specimens were cut, embedded and observed for resin/dentin interfaces under a scanning electron microscope.

Results: For the microleakage test, there were no significant differences in microleakage among the groups on both the enamel and dentin margin. No statistically significant differences were found between microleakage of the loaded and unloaded groups on enamel margins for all materials. There were statistically significant differ-

Pong Pongprueksa, DDS, MSc, lecturer, Department of Operative Dentistry, Faculty of Dentistry, Mahidol University, Bangkok, Thailand

Watcharaporn Kuphasuk, DDS, MSD, diplomate American Board in Operative Dentistry, assistant professor, Mahidol University, Bangkok, Thailand

*Pisol Senawongse, DDS, MSc, PhD, lecturer, Department of Operative Dentistry, Faculty of Dentistry, Mahidol University, Bangkok, Thailand

*Reprint request: 6 Yothi Street, Phayathai, Bangkok 10400, Thailand; e-mail: dtpse@mahidol.ac.th

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ences between microleakage of the loaded and unloaded groups on the dentin margin for Groups 3 and 4. For the microtensile test, the significant difference was found between Groups 1 and 4 for the unloaded groups. For the loaded groups, there were no significant differences between Groups 1 and 2 and Groups 3 and 4. There were no statistically significant differences in microtensile bond strength between the loaded and unloaded groups except for Group 2.

Conclusion: The application of filled adhesive or low viscosity resin had no influence on marginal leakage at both the enamel and dentin margin but it had an influence on the microtensile bond strength to dentin of Class V restorations. Occlusal loading significantly increased the degree of marginal leakage at the dentin margin when low viscosity was applied in combination with either unfilled or filled-adhesives, but it decreased dentin bond strength in the group treated with only filled adhesive.

INTRODUCTION

The demand for the restoration of crown-root dentin defects, such as cervical erosion and root caries, has been significantly increased. Resin composite is one of the materials of choice, because of high esthetics. The success of resin composite restorations is due to many factors. One of the important factors is the characteristic polymerization of resin-based composites. Shrinkage due to polymerization probably causes marginal leakage, tooth fracture, resin composite fracture and dislodgement of the restoration. Contraction stress from polymerization relates to the flow capacity reduction of the composite when it is more constrained, the amount of volumetric shrinkage and the stiffness of resin composites.[1-2] An elastic bonding area at the tooth/resin interface has been proposed as an inherent buffer to compensate for polymerization contraction stress of the restorative resin.[3] Various materials have been introduced to serve as an elastic wall under restorations, such as filled adhesive resins, low viscosity resins or flowable composites. However, there is limited information on the performance of these materials. Clinical success with composite restorations is fundamentally dependent on effective, durable adhesion to enamel and dentin,[4-6] especially under occlusal loading. Occlusal force might also be partly responsible for the development of cervical lesions and failure of Class V restorations.

Bonding to enamel using an acid-etch technique is now accepted as clinically reliable. However, dentin is still an unpredictable substrate for adhesion.[7] Much of today's literature regarding filled adhesives indicates that the application of these materials, or flowable composites, under a restoration can provide a stress-relief function that compensates for stress resulting from composite polymerization shrinkage and occlusal forces.[8-9] The increased bond strength and decreased marginal leakage may result from using materials as a stress-relief function.

Because there are limited studies under mechanical loading, there is interest in studying the application of low viscosity resin or filled-adhesive resin as an elastic cavity wall in Class V restorations under occlusal loading.

This study evaluated the effectiveness of filled adhesive resin or low viscosity resin as an elastic cavity wall in Class V resin composite restorations under mechanical loading by measuring the marginal leakage on enamel and dentin margins and the microtensile bond strength to dentin at the dentin margin. There were four null hypotheses in this study: 1) there are no significant differences in microleakage among selected materials used as intermediate layers of Class V resin composite restorations; 2) there are no significant differences in microleakage with and without occlusal loading between Class V resin composite restorations; 3) there are no significant differences in microtensile bond strength among selected materials used as intermediate layers of Class V resin composite restorations and 4) there are no significant differences in microtensile bond strength with and without occlusal loading between Class V resin composite restorations.

METHODS AND MATERIALS

Fifty-six freshly extracted sound, human premolars without decay, cracks or restorations were used in this study. After extraction for orthodontic reasons, the teeth were cleaned with pumice and kept in 0.1% thymol solution at 4°C before use. Figure 1 summarizes the steps used in the preparation of the samples. A Class V cavity was prepared with a water-cooled high-speed handpiece and a cylindrical diamond bur (D8, Intensive, Lugano-Grancia, Switzerland) at the cemento-enamel junction on the buccal surface of the teeth (Figure 1). A bur was used only to prepare four cavities, then, a new bur was used. The cavity size was 4.0 mm long x 2.6 mm wide x 2.0 mm deep. The occlusal margin of the cavity was located on enamel, while the gingival margin was located on cementum. The prepared teeth were further randomly assigned to four groups of 14 teeth each and were restored immediately after tooth preparation.

Restorative Procedures

Materials used in this study and their compositions are given in Table 1. The prepared teeth from each group were restored according to the following conditions.

Group 1: All cavity surfaces were etched with 35% phosphoric acid (Scotchbond Etchant gel, 3M ESPE, St Paul, MN, USA) for 15 seconds, rinsed for 10 seconds

Table 1: *Composition of the Materials Used in This Study*

Material	Batch #	Type	Compositions
Scotchbond Etchant gel (3M ESPE, St Paul, MN, USA)	20041126	Etching agent	Water 55-65%, Phosphoric Acid 30-40%, Synthetic amorphous silica 5-10%
Adper Single Bond (3M ESPE, St Paul, MN, USA)	20040527	Primer-adhesive	Ethyl alcohol 30-40%, Bisphenol A diglycidyl ether dimethacrylate 15-25%, 2-hydroxyethyl methacrylate 10-20%, glycerol 1,3-dimethacrylate 5-15%, Copolymer of acrylic and itaconic acids 5-15%, Diurethane dimethacrylate 2-8%, Water 2-8%
Adper Single Bond 2 (3M ESPE, St Paul, MN, USA)	20041016	Primer-adhesive	Ethyl alcohol 25-35%, Bisphenol A diglycidyl ether dimethacrylate 10-20%, Silane treated silica (nanofiller) 10-20%, 2-hydroxyethyl methacrylate 5-15%, Glycerol 1,3-dimethacrylate 5-10%, Copolymer of acrylic and itaconic acids 5-10%, Diurethane dimethacrylate 1-5%, Water <5%
Filtek Flow (3M ESPE, St Paul, MN, USA)	20050527	Flowable light cured composite	Silane treated ceramic 55-65%, Bisphenol A diglycidyl ether dimethacrylate 10-20%, Triethylene glycol dimethacrylate 10-20%, Silane treated silica 5-10%, Functionalized dimethacrylate polymer <5%, Water <2%
Filtek Z250 (3M ESPE, St Paul, MN, USA)	20050406	Light cured composite	Silane treated ceramic 75-85%, Bisphenol A polyethylene glycol diether dimethacrylate 5-10%, Diurethane dimethacrylate 5-10%, Bisphenol A diglycidyl ether dimethacrylate <5%, Triethylene glycol dimethacrylate <5%, Water <2%

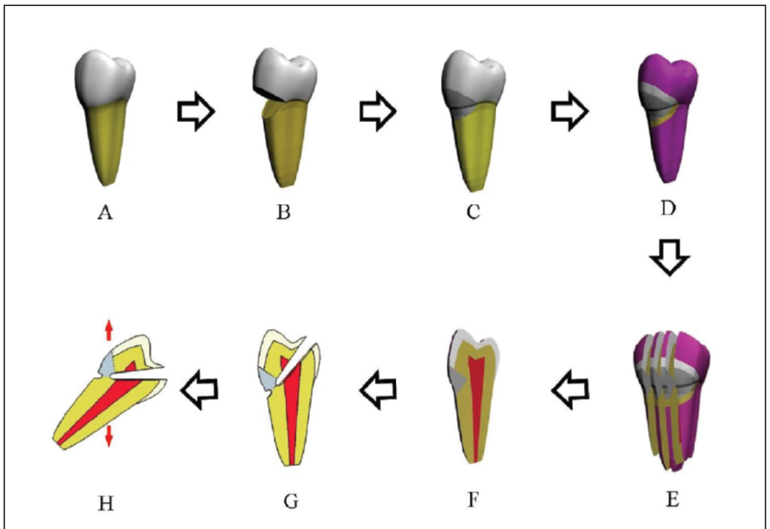

Figure 1: *Schematic indication of the methodology (A = sound human premolar tooth, B = Class V buccal preparation, C = Class V composite restoration, D = application of nail varnish, E = bucco-lingually section, F = 0.7 mm thick slab, G = dumbell shaped specimen preparation and H = microtensile bond strength evaluation).*

and blot dried with a gentle blow of air. Two coats of bonding (Adper Single Bond, 3M ESPE) were applied on enamel and dentin. The bonded specimen was gently dried for five seconds, then light-cured for 10 seconds using a halogen curing unit (Eliper Trilight, 3M ESPE) operated in standard mode emitting more than 700 mW/cm^2 irradiance, as measured with a radiometer (Model 100, Demetron Corp, Danbury, CT, USA). A resin composite (Filtek Z250, 3M ESPE) was placed into the cavity using the bulk technique and cured for 40 seconds. Finishing and polishing with an abrasive disk (Soflex Disk, 3M ESPE) were performed immediately after polymerization. Four grades of abrasive disks were used. Consequently, one minute of each grade of abrasive disk was applied on the surface under dry conditions using a slow speed handpiece running at 12,000 rpm.

Group 2: The restorative procedures were performed as previously described in Group 1 except that bonding was performed using Adper Single Bond 2 (3M ESPE).

Group 3: The bonding steps were performed in the same way as previously described in Group 1. Before restoration with the resin composite, the bonded cavity surfaces were prepared with a flowable composite (Filtek Flow, 3M ESPE) and gently air blown to obtain a thin layer of the material.

This layer was cured for 20 seconds. Then, the cavity was restored with resin composite in the same way as previously mentioned in Group 1.

Group 4: The restorative procedures were performed, as previously described in Group 3, except that bonding was performed using Adper Single Bond 2 (3M ESPE).

After finishing, the specimens were stored in distilled water at 37°C for 24 hours.

Application of Cyclic Loading

The restored teeth from each group were further divided into two subgroups of seven teeth each. One group was used as a control, with no mechanical loading. The other group was used as an experimental group with mechanical loading of the specimens. All the specimens were embedded in a self-cured acrylic resin (Instant Tray Mix, Lang Dental Manufacturing Co, Inc, Wheeling, IL, USA). After the resin had set, the specimens in the experimental group were settled on a loading machine. Mechanical stress was stimulated at a frequency of 1.5 Hz for 250,000 cycles with the loading of 50N in water in a cyclic loading machine. The load force was applied parallel to the long-axis of the tooth at the central groove using a 2 mm diameter aluminum steel rod indenter. Five teeth from each group were subjected to microleakage and microtensile testing, and the remaining two teeth in each group were subjected to a micromorphology evaluation of the resin-dentin interfaces.

Evaluation of Micromorphology of Resin-dentin Interfaces

Two teeth selected from each group were sectioned bucco-ligually using a low speed saw with a diamond blade and kept in 10% buffer formalin for 24 hours. The specimens were then rinsed under tap water and embedded in epoxy resin in a PVC ring. After 24 hours, the embedded sections were polished with wet silicon carbide paper of decreasing abrasiveness (600; 800; 1,000; 1,200 grit) and polished with diamond paste down to a 0.25 µm grain. The polished specimens were subjected to argon ion beam etching (EIS-1E, EIS-1E, Elionix Ltd, Tokyo, Japan) for seven minutes. Operating conditions for the argon ion beam etching were accelerating voltage of 1 kV and an ion current density of 0.2 mA/cm^2, with the ion beam directed perpendicular to the polished surface. The dried specimens were sputter-coated, and the resin-dentin interface observed under a scanning electron microscope (Model JSM 5410 LV, JEOL Company, Tokyo, Japan) at 1,500 and 3,500 magnifications.

Evaluation of Microleakage

Five teeth per each group were sealed with two coats of nail varnish by leaving a 1 mm window around the restorations. The sealed specimens were then immersed in 2% methylene blue dye solution at room temperature for four hours.

After immersion, the specimens were cleaned by rinsing under tap water and sectioned bucco-lingually into two slabs, 0.7 mm thick, using a low-speed diamond saw. The dye penetration and thickness of the bonding and intermediate layer at the resin-tooth interfaces were observed and measured under a measuring microscope (Measurescope MM-11C, Nikon, Tokyo, Japan). The specimens were observed under hydrated conditions by putting the specimens on hydrated gauze and observing them under the microscope. Dye penetration was recorded in mm at the occlusal and gingival margins under the measuring microscope (Figure 2).

Evaluation of Microtensile Bond Strength

The dye leakage tested specimens from each group were subjected to microtensile testing. The hydrated slabs of specimens were trimmed at the gingival wall into a dumbbell-shape using a super-fine diamond point bur under water coolant (Figure 1). The cross-sectioned area at the resin-dentin interface was approximately 1.0 mm^2. The trimmed specimens were attached to a testing apparatus (Bencor-T Multi testing apparatus, Engineering, Danville, CA, USA) using a cyanoacrylate adhesive (Model Repair II Blue, Dentsply-Sankin, Tokyo, Japan) on a universal testing machine (Instron Model 5566LV, Instron, Buckinghamshire, UK). The tensile forces were applied at a crosshead speed of 1 mm/minute. The fracture strength was calculated from the maximal force using the attached computer, then it was converted into MPa.

Evaluation of Fracture Modes

Fractured specimens from microtensile bond strength testing were kept in 10% buffered formalin for 24 hours. Upon completion of the storage time, the specimens were rinsed under tap water and attached onto a metal stub. The attached specimens were observed for failure modes under a scanning electron microscope. The failure modes were classified as adhesive failure, cohesive failure in resin and cohesive failure in dentin.

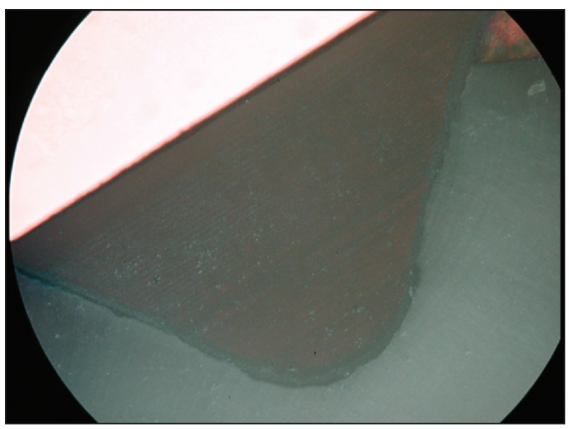

Figure 2: Microscopic image under measuring microscope (25x).

Table 2: *Microleakage (mean ± SD) of unloaded group. E leakage = microleakage at enamel margin; D leakage = microleakage at dentin margin.*

Group (unload)	E Leakage (mm)	D Leakage (mm)
1 (SB1)	0.017 ± 0.040[a]	0.285 ± 0.114[b]
2 (SB2)	0.000 ± 0.000[a]	0.366 ± 0.128[b]
3 (SB1+Flow)	0.011 ± 0.028[a]	0.272 ± 0.074[b]
4 (SB2+Flow)	0.000 ± 0.000[a]	0.261 ± 0.151[b]

The data with the same superscript demonstrates no statistically significant differences.

Table 3: *Microleakage (mean ± SD) of loaded group. E leakage = microleakage at enamel margin; D leakage = microleakage at dentin margin.*

Group (load)	E Leakage (mm)	D Leakage (mm)
1 (SB1)	0.025 ± 0.046[a]	0.408 ± 0.229[b]
2 (SB2)	0.000 ± 0.000[a]	0.406 ± 0.104[b]
3 (SB1+Flow)	0.023 ± 0.081[a]	0.454 ± 0.066[b]
4 (SB2+Flow)	0.000 ± 0.000[a]	0.414 ± 0.147[b]

The data with the same superscript demonstrates no statistically significant differences.

Table 4: *Microtensile bond strength (mean ± SD) in MPa.*

Group	Unload	Load
1 (SB1)	22.83 ± 4.61553[a]	19.5475 ± 5.22445[c]
2 (SB2)	23.9403 ± 6.23087[a,b]	18.6792 ± 4.84374[c]
3 (SB1+Flow)	27.2142 ± 4.10959[a,b]	25.98 ± 7.71375[d]
4 (SB2+Flow)	28.3133 ± 6.2499[b]	28.5625 ± 6.43689[d]

The data with the same superscript demonstrates no statistically significant differences.

The fractured areas were recorded by the percentage of each category of failure mode.

RESULTS

Micromorphology of Resin-dentin Interfaces

SEM micrographs of the resin-dentin interfaces are demonstrated in Figure 3A-H. Penetration of the resin into the dentinal tubules and the formation of a resin-dentin interdiffusion area or hybrid layer were observed for all groups. The thickness of the hybrid layers was approximately 3-6 µm when SB1 and SB2 were applied. A well-defined resin/dentin interface without any separation was observed for both the loaded and unloaded groups.

Thickness of Adhesive Layers and Intermediate Resin Layers

The thickness of the adhesive and intermediate resin layers are demonstrated in Figure 4. The statistical analysis was performed using one-way ANOVA. The film thickness of Single Bond and Single Bond 2 for all groups under unloaded and loaded conditions was not significantly different (p=0.079), with a mean value of 0.025 mm. The thickness of Filtex Flow under unloaded and loaded conditions was not significantly different (p=0.49), with a mean value of 0.082 mm.

Microleakage

The means of microleakage at the enamel and dentin margins are shown in Tables 2 and 3 and Figures 5 and 6. By eliminating the tooth region factor, statistical analysis was performed using two-way ANOVA to analyze two factors (types of intermediate layer and loading conditions) and Dunnett's multiple comparisons at a 95% confidence interval. The Levene's test for homogeneity of variance demonstrated a p-value<0.05. Within unloaded or loaded specimens, there were no significant differences in microleakage among the groups on both the enamel and dentin margins (p=0.098, p=0.607). No statistically significant differences were found between microleakage of the loaded and unloaded groups on the enamel margin for all materials (p=0.512). There were statistically significant differences between microleakage of the loaded and unloaded groups on the

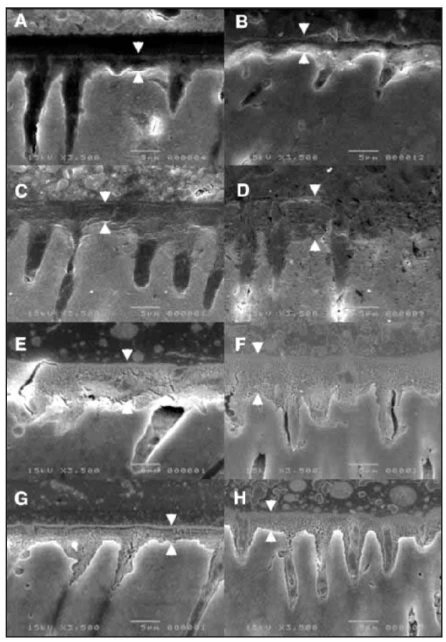

Figure 3: *SEM image of the resin-dentin interface at dentin margin of unloaded groups (Group 1 [A], Group 2 [B], Group 3 [C], Group 4 [D]) and loaded groups (Group 1 [E], Group 2 [F], Group 3 [G] and Group 4 [H]). Arrows indicates thickness of the hybrid layer (3500x).*

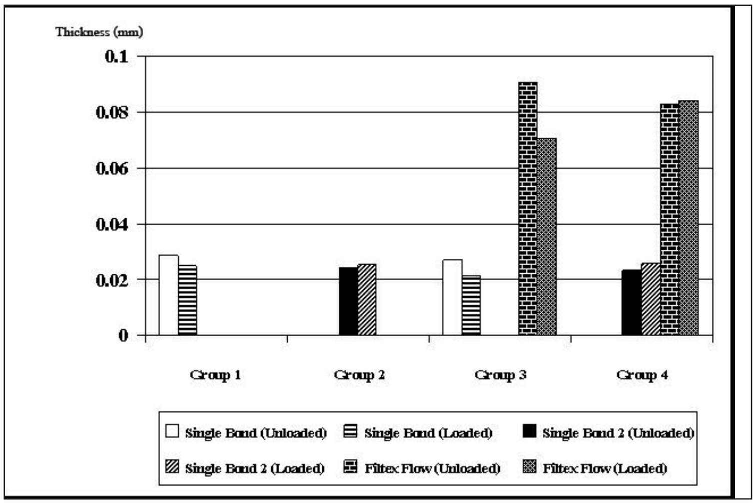

Figure 4: *The thickness of adhesive and intermediate resin layers.*

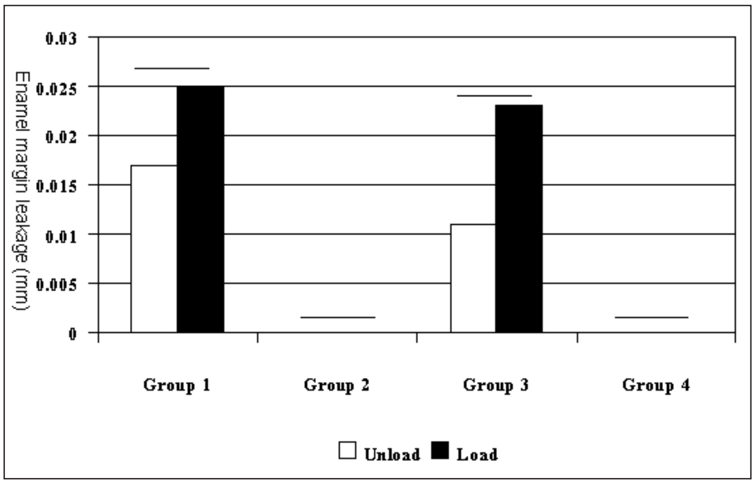

Figure 5: *Comparison of microleakage (mean) at the enamel margin of unloaded and loaded Class V restorations. The data under the horizontal lines demonstrate no statistically significant differences.*

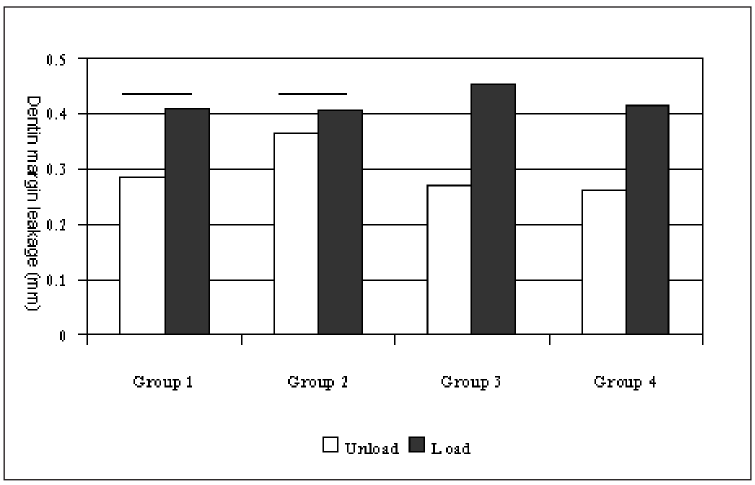

Figure 6: *Comparison of microleakage (mean) at the dentin margin of unloaded and loaded Class V restorations. The data under the horizontal lines demonstrates no statistically significant differences.*

dentin margin for Groups 3 and 4 (p=0.000, p=0.021).

The differences in microleakage between the enamel and dentin margins of each group were analyzed using the independent student t-test at a 95% confidence interval. The dentin margins had significantly higher microleakage than the enamel margins ($p<0.05$).

Microtensile Test

The means microtensile bond strengths and standard deviations are shown in Table 4 and Figure 7. The results were statistically analyzed using two-way ANOVA to analyze two factors (types of intermediate layer and loading conditions) and LSD multiple comparison at a 95% confidence interval. The Levene's test for homogeneity of variance demonstrated a p-value = 0.366. For the unloaded group, there were no significant differences in microtensile bond strength among Groups 1, 2 and 3 and Groups 2, 3 and 4. A significant difference was found between Groups 1 and 4 at p=0.016. For the loaded group, there were no significant differences between Groups 1 and 2 and Groups 3 and 4 (Table 4). There were no statistically significant differences in microtensile bond strength between the loaded and unloaded groups except for Group 2 (p=0.031) (Figure 7).

The percentages of failure mode in the unloaded and loaded conditions are shown in Figures 8A and 8B. Adhesive failure was prominently observed in all groups. For statistical analysis, one-way ANOVA and Dunnett's multiple comparison were applied at a 95% confidence interval. There were no significant differences in the percentage of failure among the groups under unloaded conditions. Nevertheless, statistically significant differences in the percentage of failure were found under a loaded condition.

In the loaded condition, the groups with flowable composite applied demonstrated higher percentages of cohesive failure within resin than the other groups. Significant differences in percentage of failure were found between the SB1 and SB2-Flow groups ($p<0.01$) and the SB2 and SB2-Flow groups ($p<0.01$).

When the failure mode of the loaded and unloaded groups were compared, statistically significant differences were found only between the loaded and unloaded groups of SB1-Flow (p=0.016).

DISCUSSION

The elastic cavity wall created by the application of either a low viscosity resin[8] or a filled-adhesive resin has been proved.[10-11] This wall acts as an inherent buffer to compensate for the polymerization con-

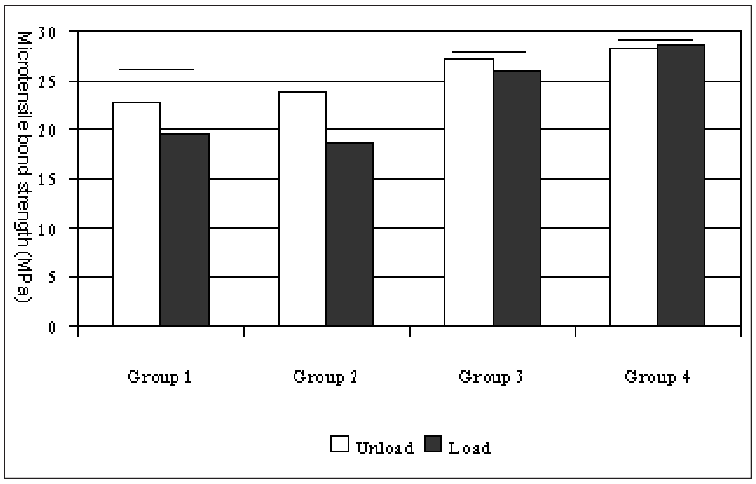

Figure 7: *Comparison of microtensile bond strength (mean ± SD) at the dentin wall of unloaded and loaded Class V restorations. The data connected with the horizontal lines demonstrate no significant differences.*

traction of resin composites[8] and transfers occlusal stress to under the tooth structure. Therefore, reduction in the failure rate of composite restorations can be obtained *in vitro*.[12] Two testing conditions were performed in this study. First, the unloading condition was used as a control group to evaluate the effect of contraction stress of resin composite on microleakage. Second, to simulate the clinical situation, the loading condition was used as an experimental group to evaluate the effect of occlusal loading on microleakage. In this study, 50 N occlusal force was applied parallel to the long axis of the tooth for 250,000 cycles under 100% humidity. This loading condition has been verified as one year of clinical wear.[13-14]

SEM micrographs of all the groups are demonstrated in Figure 3A-3H. The thickness of the hybrid layers was approximately 3-6 µm for both Adper Single Bond and Adper Single Bond 2, which is similar to a previous study.[15] The resin dentin interfaces might have the ability to resist the contraction stress generated by polymerization shrinkage and occlusal loading, thereby establishing a good bond to dentin without any gap formation, as confirmed by a previous study.[6] The addition of fillers into the adhesive system had no effect on the micromorphology of the hybrid layer under SEM.

In Class V restorations, thicker layers of relatively low modulus resin or adhesive can significantly reduce the contraction stress of resin composites and, consequently, reduce the overall degree of marginal leakage.[16-18] The thickness of these layers was measured and statistically analyzed. Statistical analysis confirmed no significant difference in thickness. Thus, the effect of thickness of the adhesive and low viscosity resin layers could be excluded from this study.

Methylene blue was used in this study because of its contrasting color. Additionally, this dye has been proven to have no chemical reaction or cause no destruction to the specimens.[19-23]

Marginal seal is one of the most important factors for the success of a restoration. Many studies have shown that bonding of the restorative materials to enamel is adequate to resist contraction stress.[3,5,7,20-23] In this investigation, all restorations demonstrated less microleakage at the occlusal margins than at the dentin margins, due to the effectiveness of the acid-etch technique in sealing cavity margins on enamel. Various degrees of microleakage occurred along the gingival margins that were placed on dentin. Currently, the resin composite restorations of the cavities having margins partially or totally located in dentin are still an unsolved problem.

The efficiency of filler containing an adhesive or the low viscosity resin layer used to reduce microleakage on both the enamel and dentin margins was not exhibited in this study. No significant differences in microleakage among the groups were found. This indicated that the filled-adhesive and flowable resin composite could not

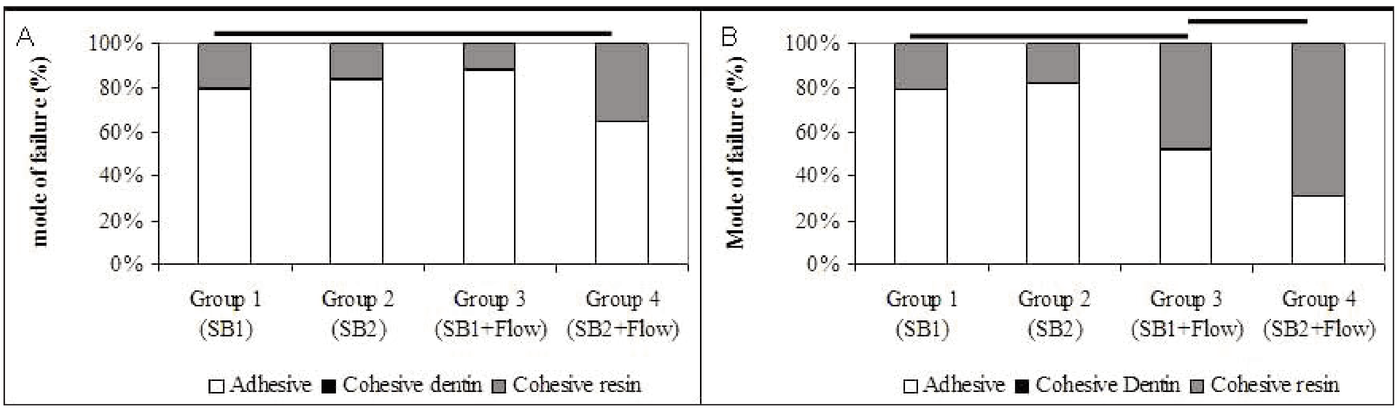

Figure 8: *Mode of failure (%) under unloaded (A) and loaded conditions. The data connected with the horizontal line demonstrates no statistically significance difference.*

decrease microleakage caused by polymerization contraction of the resin composite in all groups. The results of this study were comparable to previous studies in which significantly less leakage in Class V cavities was not found when filled adhesive was applied.[23-24] In contrast, several authors have reported encouraging results in reducing microleakage with the use of flowable composite restorative materials.[25-26] This is probably due to a relatively small C-factor (approximately 1.3); polymerization contraction stress might not exceed the bond strength of filled and unfilled adhesive resin, regardless of the composite used. When loading force was applied, increased marginal leakage was exhibited only at the dentin margin. There were no statistically significant differences in microleakage at the enamel margin for all materials. This explanation might result from the highly effective enamel bond of the total-etching adhesive system[5] even under occlusal loading. There was a statistically significant difference in microleakage at the dentin margin between unloaded and loaded conditions in Groups 3 and 4. Use of a flowable composite in Groups 3 and 4 in the loaded condition demonstrated higher microleakage at the dentin margin compared with the unloaded condition. It seems that low viscosity resin had a negative effect on marginal leakage at the dentin margin. The thick layers of low viscosity resin with low elastic modulus might present a defect within the thick layers after occlusal loading, which caused a high degree of marginal leakage compared with the other groups. Further study may be necessary to confirm this result.

When comparing leakage between the enamel and dentin margins, leakage at the dentin margin was significantly higher than at the enamel margin for both the loaded and unloaded condition, which confirmed previous results.[27-28] This indicated that all enamel margins were fairly well sealed. The enamel roughness created by acid etching might be sufficiently pronounced to offer adequate micromechanical retention and sealing ability, even under loading conditions.

For the bond strength test, the microtensile bond strength method was used in this study. This method has demonstrated advantages over the traditional test method. The microtensile test enables more accurate measurement, because the hourglass design of the specimen imposes the highest uniform distributions of stress during testing. The uniform stress distribution has been claimed to reduce the scatter of bond values and achieve high bond strength.[29-31] In addition, this method permits the investigation of interfacial bond strength on areas smaller than 1 mm^2, which is very practical in this study of Class V restorations.[32]

For the unloaded condition, there were no significant differences in microtensile bond strength among Groups 1, 2 and 3 and Groups 2, 3 and 4. However, there was a significant difference between Group 1 and 4. The application of low viscosity resin onto unfilled adhesive resin or filled adhesive resin, as a stress absorber, could not improve microtensile bond strength when compared with the application of only filled adhesive resin.

Microtensile bond strength for the loaded group demonstrated no significant differences between Groups 1 and 2 and Groups 3 and 4. The application of low viscosity resin resulted in increasing bond strength at the dentin margin of Class V restorations. This result indicated that a flowable composite could improve microtensile bond strength by resisting the force from occlusal loading. The use of a low viscosity resin, combined with an adhesive system, might have a higher strain capacity to relieve stresses between composite restorations and the rigid dentin substrates caused by occlusal loading.[33]

The application of filled adhesive both under unloaded and loaded conditions did not improve bond strength when compared to the unfilled adhesive group, which is in line with previous studies.[34-35] The improvement of bond strength by applying filled adhesive, as proposed by Fanning and others,[9] could not be observed in this study.

The effect of loading to bond strength was also investigated. It had an influence when the filled adhesive was applied.

After bond strength testing, the fractured specimens were further observed under SEM. The application of low viscosity resin as a stress absorber tended to increase bond strength and increase the percentage of cohesive failure in resin. Increasing cohesive failure in resin was observed clearly in Group 4, especially under a loaded condition. The thick layers of low viscosity resin with low elastic modulus might be damaged and present defects after occlusal loading, causing an increase in the percentage of cohesive failure, in this thick layer.

CONCLUSIONS

Within the limitation of this experiment, it can be concluded that:

1. The application of filled adhesive or low viscosity resin had no influence on marginal leakage both at the enamel and dentin margin.
2. Occlusal loading significantly increased the degree of marginal leakage at the dentin margin when low viscosity was applied in combination with either unfilled or filled adhesives.
3. The application of filled adhesive or low viscosity resin had an influence on the microtensile bond strength to dentin of Class V restorations.

4. Occlusal loading significantly decreased dentin bond strength in the group that was treated by only adhesive resins.

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