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Laboratory Research

Role of Additional Retention on Marginal Adaptation and Sealing of Large Resin Composite Class II Restorations

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Clinical Relevance

Retention grooves in proximal box cavities can minimize microleakage and improve marginal adaptation of large resin composite Class II restorations.

SUMMARY

Purpose: To compare marginal leakage and gap formation in large resin composite Class II cavities with their gingival margins in cementum, using three different additional retentions in the proximal box. Methods: Standardized large Class II MOD cavities with gingival margins in cementum were prepared in 40 recently extracted molars and divided into four groups according to their retention in the proximal box: (G1) no retention; (G2) vertical grooves in the buccal and lingual walls; (G3) "pot holes" in the gingival wall and (G4) horizontal grooves in the gingival wall. All groups were restored with the incremental technique using the same resin composite (QuiXfil, Dentsply) and a bonding agent (Prime Bond NT, Dentsply). After polishing, all of the restored teeth were immersed in dye solution and submitted to simultaneous cyclic loading. Impressions of the gingival margins were made before and after loading, and epoxy resin replicas were evaluated for gap formation using a scanning electron microscope. The microleakage and gap extension data were evaluated by ANOVA and Tukey's test (*p*<0.05). Gap extension before and after mechanical loading was compared by Student's *t*-test. A correlation analysis was made between the gap extension and microleakage (Pearson's correlation test).

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Results: All groups with additional retention (G2=0.565, G3=0.346 and G4=0.078) showed fewer gap formations than the control group (G1=2.076). Similar results were found for microleakage tests. All groups presented an increase in gap extension after loading, with the exception of the group with gingival retention grooves (G4). G4 showed the best results in relation to both parameters. There was a low correlation between gap extension and microleakage.

INTRODUCTION

Continuous progress of dentin adhesive systems, along with the technological development of dental materials, has allowed resin composites to be placed in posterior teeth. Early in 1983, the recommendations of the American Dental Association (ADA) stated that resin-based materials were not yet suitable to replace amalgam in posterior restorations subjected to occlusal forces.[1] However, in 1988, the ADA's recommendations supported the use of resin composites in initial and moderately-sized Class I and Class II restorations.[2]

A major disadvantage of resin composite material in Class II cavities is its marginal integrity. Polymerization shrinkage caused by insertion contraction and hardening of the restorative material can result in a poor marginal seal of the final restoration, despite the use of advanced dentin and enamel adhesive systems.[3] Sealing is more difficult to obtain when the margins are located below the cementoenamel junction (CEJ).[4-8] The inability of a restorative material to seal the interface with tooth structure encourages the microleakage of intraoral irritants and results in the development of sensitivity, bacterial infiltrations and secondary caries.[9-10]

Several measures have been proposed to minimize this phenomenon, including incremental resin composite insertion,[5,11-15] the use of adhesives for the external sealing of microgaps[16-17] and the use of self-etching adhesive systems.[6,18-20] All measures offer good results for margins located in enamel; however, the quality of the marginal sealing of adhesive restorations located in dentin did not reach the same results.

Ben-Amar, Metzger and Gontar[21] were the first to suggest that, for resin composites, retentive grooves should be used in the gingival wall of Class II cavities. According to these authors, the grooves would act as mechanical retention, thus reducing the marginal retraction caused by polymerization contraction. Later, Ben-Amar and others[22] showed that the incremental technique significantly reduced marginal leakage, but when this technique was not used and resin composite was placed in bulk, retentive grooves were needed to reduce microleakage.

According to Coli, Blixt and Brännström,[23] the number of retention grooves is also important; they showed that the use of one retention groove reduced the length of the contraction gap, but not as much as two retention grooves.

However, some authors found that the additional retention was not needed in adhesive restorations.[24-26] The lack of size in standardized cavities and their location in the gingival margin confused the results and did not reveal their real contribution, that of additional retention.

This study evaluated the effect of additional retention on marginal adaptation and sealing of large resin composite Class II restorations in cavities that need improvements in both parameters.

METHODS AND MATERIALS

Forty human third molars stored in 0.9% saline solution and 0.1% thymol right after extraction were selected for this study. All the teeth had the occlusal surface ground flat 4 mm above the cementum-enamel junction (CEJ) to standardize the occlusal and proximal dimensions of Class II cavities, especially the proximal box height.[27]

Additional silicon impressions (Aquasil, Dentsply, Petrópolis, Brazil) were taken of the external surface of all teeth before cavity preparation, using the double impression technique. These impressions were used as a proximal matrix during the insertion of resin composite to minimize marginal excess and favor microgap analysis during scanning electron microscopy (SEM).

Class II MOD cavities were prepared with diamond burs (#1151 KG Sorensen, São Paulo, Brazil) in a turbine handpiece with cooled water-spray. Finishing was performed with carbide burs at low speed. Cavity dimensions were at an occlusal depth of 2.0 mm and an occlusal bucolingual width of 4.0 mm; a proximal depth of 2.0 mm and a proximal buccolingual width of 5.0 mm and the gingival margin located 1 mm below the adjacent CEJ. All internal angles were rounded.

The specimens were divided into four groups, according to the type of additional retention design of the proximal box (Figure 1):

Group 1—no additional retention (control group).

Group 2—vertical grooves in the buccal and lingual wall with a 0.5 mm depth and 1.0 mm above the pulpal floor.

Group 3—two "pot holes" with a 1.0 mm depth located in the gingival wall of the proximal box 1.5 mm from the buccal and lingual walls and 1.0 mm from the cavosurface margin (Carbide bur #329, SS White, Rio de Janeiro, Brazil).

Group 4—a horizontal groove at a depth of 1.0 mm along the gingival wall (from the buccal wall to the lingual wall) and 1.0 mm distance from the cavosurface margin (Carbide bur #329, SS White).

All the teeth were restored with resin composite (QuiXfil, Dentsply, Petrópolis, Brazil) and bonding agent (Prime Bond NT, Dentsply) according to the manufacturer's instructions. The incremental technique was used for the restorations: two diagonal increments were inserted in the proximal box to reach the level of the occlusal box, then two larger diagonal increments were used for the occlusal box to finish the restoration. Amalgam condensers were used to insert the first increment of the proximal box against the gingival wall. Smaller amalgam condensers were used to insert the resin composite inside the retentions. Each increment was polymerized for 20 seconds through the occlusal face (480mW/cm^2, Ultralux Electronic, Dabi Atlante, Ribeirão Preto, Brazil). After removing the silicon matrix, each proximal face was polymerized for an additional 20 seconds.

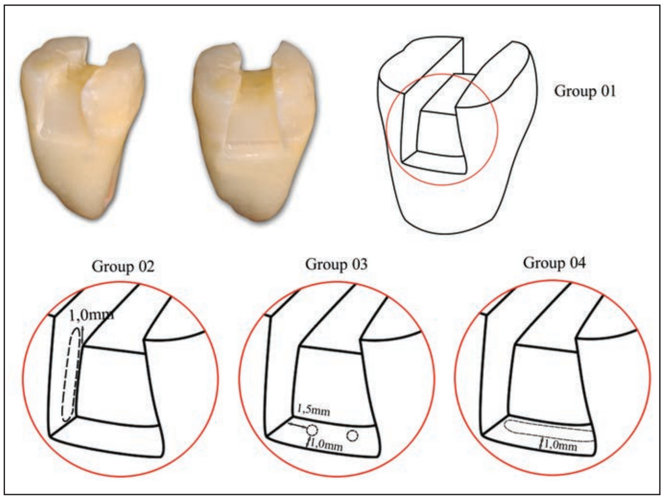

Figure 1: *Class II MOD cavities showing the additional retention design of the proximal box. Group 1, no additional retention; Group 2, vertical grooves in the buccal and lingual walls; Group 3, pins in the gingival wall and Group 4, horizontal grooves along the gingival wall.*

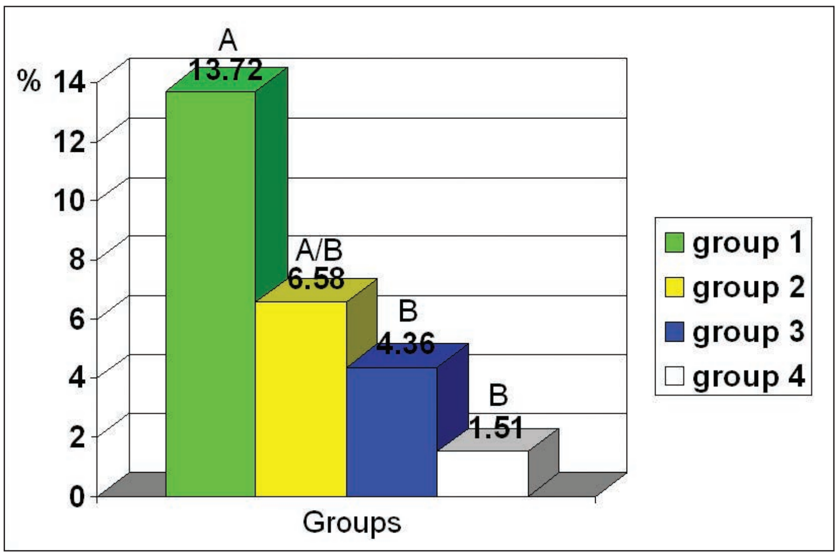

Figure 2: *Graphic representation of microgap extension before cyclic loading (different letters indicate statistically significant differences).*

After restoration, the specimens were stored in distilled water for 144 hours (six days) at 37°C to allow for water sorption to occur.[28]

The root apices were sealed with acrylic resin, and the teeth were covered with two layers of nail vanish except for the restoration and 1 mm from the margins. Samples were subjected to cyclic loading immersed in 0.5% basic fuchsin.[3,29-32] Plastic tubes were used to maintain the dye solution during cyclic loading and storage.

Cyclic Loading

An universal testing machine (EMIC, Sao José dos Pinhais, Brazil) was used for the cyclic loading test. Alternate loads of 1Kg to 17Kg were applied to the occlusal surface at 70 cycles each for 30 seconds.

After loading, the samples were maintained in dye solution for 12 hours at 37°C. Then, the samples were dried and new impressions of the gap area were taken.

Microgap Analysis

Microgap at the proximal margin was analyzed at SEM before and after cyclic loading.

For this analysis, impressions of the proximal surface were taken, following the same technique as previously described, obtaining epoxy resin replicas. The replicas were processed for analysis in SEM. The use of replicas was selected to avoid artifacts from SEM sample preparation procedures, which could result in false microgap quantities and extension.

Using photomicrographs (180x magnification) that were analyzed with Image Tools Software (Image Tools Software, UTHSCSA, University of Texas Health Science, Center San Antonio, TX, USA), the total extension of the tooth/restoration interface and extension of the marginal gap were obtained as a percentage.[33]

Microleakage Analysis

After cyclic loading, each specimen was sectioned mesiodistally (0.8 mm cuts) along the center of the restoration using a low speed diamond saw. Digital images were taken from each cut, and the same Image Tools software was used to measure the total depth of the gingival wall (axial direction) and the depth of microleakage as a percentage.[33] For each section, three measurements were taken by the same operator and a mean value was then obtained.

Group means for microgap and microleakage were calculated and compared by one-way ANOVA and Tukey's LSD test with α=0.05. A paired *t*-test was used to evaluate microgap formation before and after cyclic loading. Correlation of the microgap and microleakage was calculated using the Pearson Correlation test.

RESULTS

Figures 2 and 3 show the graphic representation of microgap values for all groups before and after loading. Figure 4 presents the SEM photomicrograph of the gingival wall demonstrating the presence of a microgap. The mean extension of a microgap before cyclic loading was 13.72% for Group 1, 6.58% for Group 2, 4.36% for Group 3 and 1.51% for Group 4. After loading, the mean extension of a microgap was significantly lower for all groups with additional retention: Group 2 (11.59%), Group 3 (7.11%) and Group 4 (1.57%) when compared to Group 1 (42.44%), which had no additional retention.

When microgap values before and after cyclic loading were analyzed, significant differences were found for Groups 1, 2 and 3, and no difference was found for Group 4 (Table 1).

Figure 5 is the graphic representation of the microleakage values for all groups after cyclic loading. Figure 6 shows the digital images of microleakage observed in Groups 1 and 4. All groups presented microleakage: 82.84% for Group 1, 64.73% for Group 2, 45.43% for Group 3 and 3.09% for Group 4.

The correlation test (Pearson Test) demonstrated a weak correlation between microgap and microleakage (r =0.47; *p*=0.00).

DISCUSSION

Class II cavities with margins located below the CEJ continue to challenge dental material technology. The major disadvantage of resin composite materials in this area is polymerization contraction.

In this study, Class II cavities were prepared using different additional retentions on the proximal box and were analyzed for microgaps and microleakage before and after cyclic loading. Despite the type of proximal box cavity design, all groups presented microgap and microleakage.

Coli, Blixt and Brännström[23] stated that the reduction of gap extension may be due to counteraction of polymerization shrinkage when the composite is locked at the retention grooves, where initial light curing

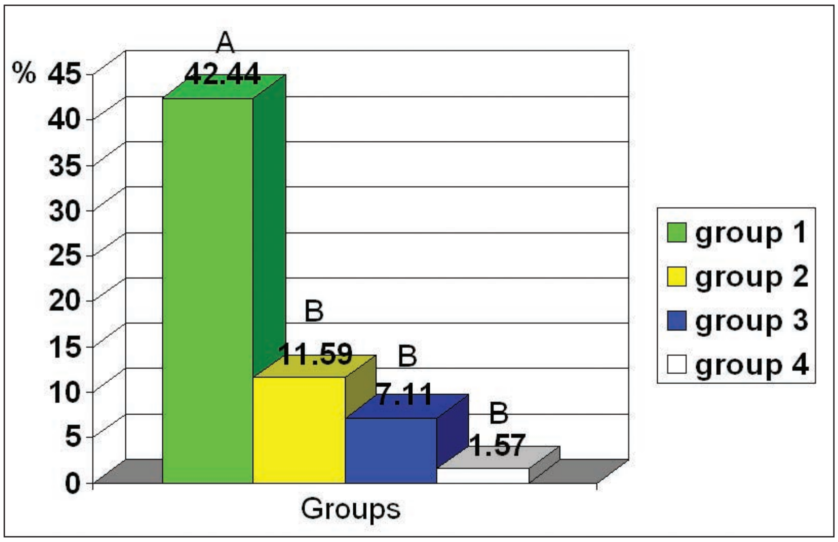

Figure 3: *Graphic representation of microgap extension after cyclic loading (different letters indicate statistically significant differences).*

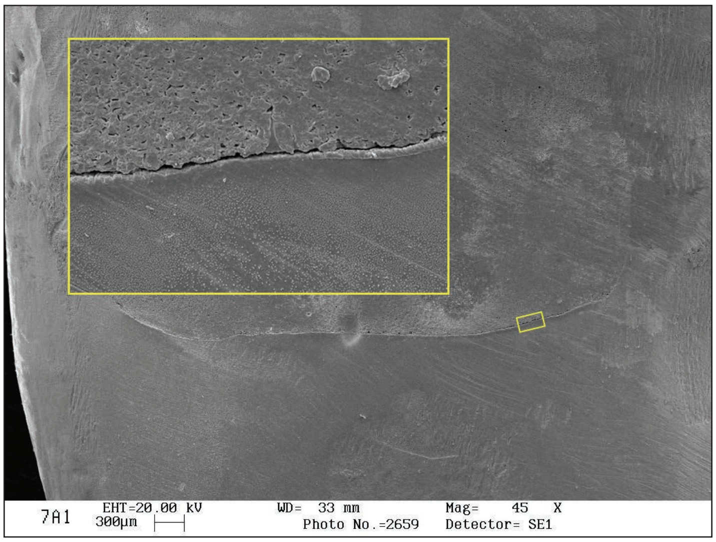

Figure 4: *SEM photomicrograph of the gingival wall demonstrating the presence of a microgap (180x magnification).*

Table 1: *Microgap Extension Mean and Standard Deviation for All Groups Before and After Cyclic Loading (%)*

	Before Cyclic Loading	After Cyclic Loading	*P*
Group 1	13.72 ± 13.13	42.43 ± 29.59	0.001*
Group 2	6.58 ± 9.97	11.59 ± 15.14	0.02*
Group 3	4.36 ± 8.78	7.11 ± 11.30	0.02*
Group 4	1.51 ± 5.69	1.57 ± 5.81	0.18

**statistically significant (p<0.05)*

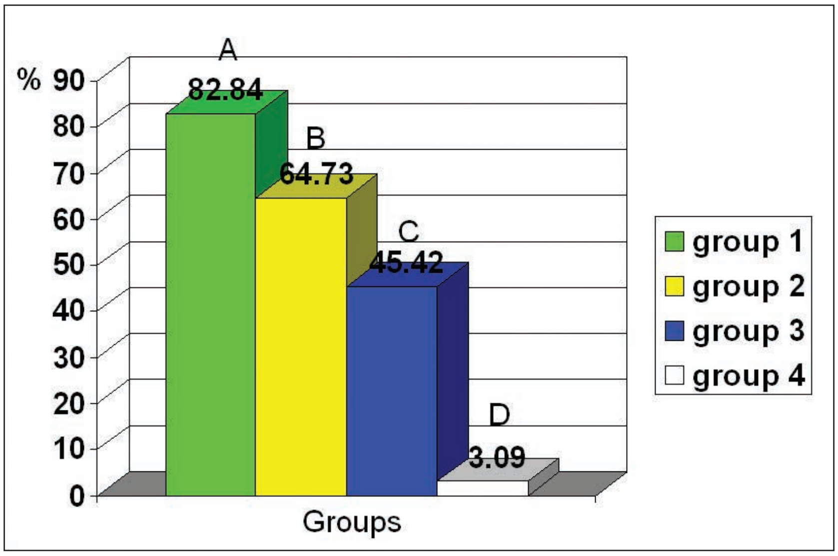

Figure 5: *Graphic representation of microleakage after cyclic loading for all groups (Note: the different letters indicate statistically significant differences).*

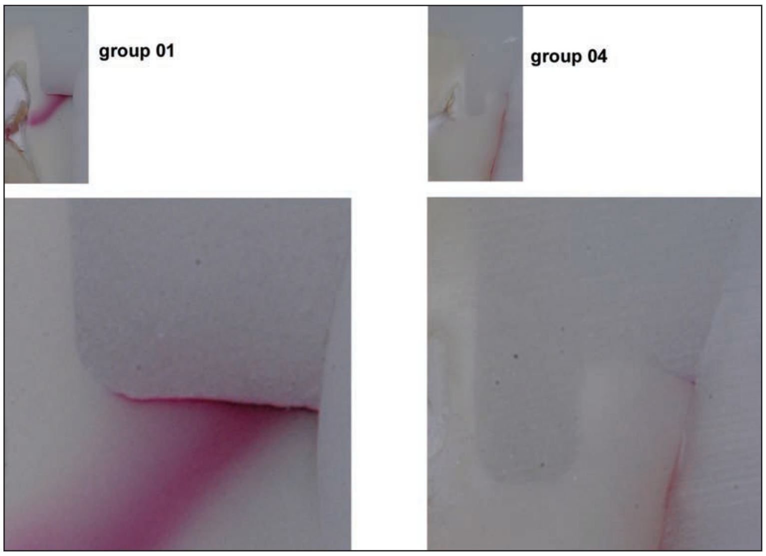

Figure 6: *Digital images of the microleakage observed in specimens of Groups 1 and 4.*

occurs. Their study demonstrated better results when two grooves were used compared to when one groove and no grooves were used. The results of the current study also demonstrated that the use of additional retention can reduce extension of the microgaps (Figures 2 and 3) when compared to Group 1, which had no additional retention. No difference was found among the groups with different additional retention: Group 4, which had a groove along the gingival wall, presented a microgap extension of 1.51%, Group 3 presented a microgap extension of 4.36% and Group 2 presented a microgap extension of 6.58%.

In order to study the potential of additional retention in preventing microgap formation and microleakage, the use of cyclic loading in the current study aimed to cause stress on the restorative material and adhesive layer. All groups presented microgaps before cyclic loading, and the reduced number of cycles used (70 cycles) was sufficient to produce stresses and microgaps in Groups 1, 2 and 3. For Group 4, microgaping was not different before and after cyclic loading (Table 1), which demonstrated that the additional retention used (grooves along the gingival wall) was adequate to keep the initial marginal seal of the restoration when it was submitted to mechanical stresses.

In this study, the use of additional retention did not prevent the presence of microleakage in all groups submitted to cyclic loading. Group 1, without any type of additional retention, presented the highest value of microleakage (82.84%), followed by Group 2 (64.73%), Group 3 (45.42%) and Group 4 (3.09%). The lowest value of microleakage observed for Group 4, with a groove along the gingival wall, indicates that the location and extension of the additional retention can reduce the effect of mechanical stress and the development of creep and flow. The groove along the gingival wall seemed to produce a larger area of adhesion and mechanical retention, reducing polymerization shrinkage and microleakage. The same results were also observed by Shahani and Menezes,[34] who demonstrated that retentive grooves on the proximal box significantly reduced microleakage after thermocycling.

A weak correlation was found between the presence of microgap and microleakage, but there was a tendency for a positive correlation. These results are in agreement with Dietschi and others,[14] who justified the weak correlation between these two parameters due to the different sensitivities of the two methods of analysis. Amaral and others[15] stated that the weak correlation is due to the different areas analyzed by each test. While it is difficult to analyze the depth of microgaps in SEM, in the microleakage analysis, this depth is easily verified. According to Holan and others,[16] it is very important to understand the difference in microgap and microleakage methodologies. When comparing both methodologies, these authors observed that SEM analysis can only offer a visual analysis of the marginal sealing of the restoration, which may not indicate microleakage sealing.

In resin composite Class II restorations with margins located in dentin, the major concern is the marginal sealing, not the retention. Additional retention on the proximal box is used to reduce microgap and microleakage in this area. The findings of this study indicate that the use of a groove along the gingival wall (Group 4) seems to be a good alternative for reducing microgaps and microleakage, even knowing that this retention design demands additional grinding of the dentin substrate and may present clinical risks.

CONCLUSIONS

Within the limitations of this study, the following conclusions can be drawn:

- The use of additional retention on the proximal box did not prevent microgap formation and microleakage in Class II MOD cavities with gingival margins located in dentin; however, a significant reduction was observed.
- A weak correlation was found between microleakage and microgap.

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