Contemporary Orofacial Sciences (2025) 3(3): 48-54
DOI:10.61882/cofs.3.3.6

CASE REPORT

In vitro comparison of cervical microleakage of Class II composite restorations performed by different techniques

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Received: 2025-04-25/ Accepted: 2025-08-23 / First publication date: 2025-09-11

Abstract

Background: This study aimed to compare the efficacy of the snowplow, open sandwich with resin-modified glass ionomer (RMGI), and flowable composite liner techniques for the reduction of cervical microleakage of posterior Class II composite restorations.

Materials and Methods: In this in vitro study, 60 class II cavities were prepared in 30 sound extracted premolars. The gingival floor of the cavities was placed 1 mm below the dentin-enamel junction. The teeth were randomly assigned to four groups (n=15). The enamel margin was etched, and SE Bond was applied. The teeth were restored with x-tra fil in group 1 (control), x-tra base + x-tra fil (snowplow technique) in group 2, RMGI + x-tra fil (open sandwich technique) in group 3, and x-tra fil + x-tra base (flowable composite liner) in group 4. After thermocycling, the teeth were immersed in 2% Fuchsin for 24 hours, and were then sectioned. Cervical microleakage of restorations was scored under a stereomicroscope at 20X magnification, and analyzed using the Kruskal-Wallis and Mann-Whitney tests ($\alpha=0.05$).

Results: The microleakage of the snowplow ($P<0.001$), open sandwich ($P=0.003$), and flowable composite liner ($P=0.05$) groups were significantly higher than that of the control group. The microleakage of the snowplow technique was also significantly higher than that of the flowable composite liner ($P=0.047$). No other significant differences were found ($P>0.05$).

Conclusion: Within the study limitations, the results indicated that the snowplow, open sandwich with RMGI, and flowable composite liner techniques were not effective in reducing cervical microleakage of class II composite restorations.

Keywords: Composite Resins; Dental Leakage; Glass Ionomer Cements

Introduction

Composite resins are commonly used for tooth-colored restoration of teeth due to advantages such as optimal esthetics, thermal insulation, and bonding to tooth structure. However, they have drawbacks as well. The main drawback of posterior composite restorations is their polymerization shrinkage (approximately 2.6% to 7.1%) (1), which can lead to debonding of the composite from the cavity walls and subsequent leakage of fluids, molecules and ions through the interface (2). Thermal alterations in the oral environment and mechanical fatigue can also cause microleakage of composite restorations (2).

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Some other factors, including type of substrate, cavity design, location of cavity margins, technique of composite application, curing technique, and finishing and polishing of restorations, can also affect the microleakage of composite restorations (3).

There is no protocol to completely prevent the microleakage. Nonetheless, techniques that prevent or compensate polymerization shrinkage can effectively decrease microleakage, and include incremental application of composite, application of flowable composite below composite restorations, the sandwich technique, and using low-shrinkage composite resins (4-6).

The sandwich technique is defined as the application of one layer of resin-modified glass ionomer (RMGI) below the composite resin. RMGI has long been used as a replacement for the lost dentin structure and has reduction of post-operative tooth hyper-sensitivity the advantages of fluoride release, reduction of polymerization stress of composite resins due to its optimal properties, such as a coefficient of thermal expansion similar to that of tooth structure, bacteriostatic property, and chemical bonding to enamel and dentin (6,7).

Evidence shows that application of RMGI liner improves marginal adaptation (8) and decreases marginal microleakage (9-11).

The snowplow technique is another suitable technique suggested for the reduction of microleakage. In this technique, a thin layer of flowable composite is applied at the cavity floor (without curing), followed by the application of a thin layer of hybrid composite over it. Next, the two layers are cured together (12). The results regarding the efficacy of this technique have been controversial. Some studies reported increased microleakage as a result of application of flowable composite (13,14), and some others found no significant difference among different flowable composites in this regard (15), no significant effect on microleakage (16), or improvement of marginal adaptation and reduction of microleakage (17).

Application of a flowable composite liner at the interface of cavity floor and restorative material has also been suggested due to its coefficient of elasticity, the stress-breaking effect of this intermediate layer on polymerization stresses by decreasing the C factor, and reducing the required volume of packable composite (18,19). Flowable composites well adapt to the cavity walls and can decrease marginal leakage. However, a previous study refuted the efficacy of the application of a flowable composite liner for the reduction of microleakage (6).

The purpose of the present study was to compare the efficacy of the snowplow, open sandwich with RMGI, and flowable composite liner techniques for the reduction of cervical microleakage of posterior Class II composite restorations. The null hypothesis of the study was that no significant difference would be found in microleakage among the four techniques.

Materials and Methods

This in vitro, experimental study was conducted on 30 sound human premolars extracted for orthodontic purposes. The study protocol was approved by the university's ethics committee (IR.UMSU.REC.1396.301). The required sample was calculated to be 15 specimens per group, based on a significance level of $\alpha = 0.05$, a power of 80% ($\beta = 0.2$), and an estimated effect size (Cohen's d) of 1, according to reference (20).

Specimen preparation:

The collected teeth were cleaned in distilled water and disinfected in 0.5% chloramine T for one week. Two standard Class II proximal cavities were prepared in the mesial and distal surfaces of each tooth by using a 0.8 mm fissure bur. The cavities had 3 mm buccolingual width, and 2 mm axial depth. All cavities were extended to 1 mm below the cementoenamel junction. None of the surface angles had beveled

[DOI: 10.61882/cofs.3.3.6]

margins, and each bur was discarded after 5 preparations. A matrix band (Tofflemire) was used for proximal restorations. The teeth were then randomly assigned to four groups (n=15 cavities) as follows:

Group 1: Enamel margin of the cavities was first etched with 37% phosphoric acid for 20 seconds, rinsed, the cavity was gently air-dried for approximately 2–3 seconds to maintain controlled dentin moisture and avoid over-drying. Next, SE Bond primer (Kuraray, Japan) was applied to the cavity walls by a micro brush as instructed by the manufacturer. After 20 seconds of gentle air spray, the bonding agent was applied, gently air-thinned, and light-cured using the LED Demi Plus (Kerr) light-curing unit for 10 seconds. Subsequently, x-tra fil bulk-fill composite (VOCO, Germany) was applied as instructed by the manufacturer. For this purpose, the first layer was applied to the gingival floor with a thickness of approximately 1 mm. The cavity was then filled using an oblique incremental approach, ensuring that the thickness of each increment did not exceed 4 mm. Each layer was cured for 10 seconds before the next layer was applied, following the manufacturer's instructions. After cavity restoration, the matrix band was removed and the restoration was irradiated from the buccal and lingual surfaces, each for 10 seconds.

Group 2: After acid-etching and application of SE Bond primer and bonding agent, a thin layer of x-tra base (VOCO, Germany) flowable composite was applied to the cavity floor with 1 mm approximate thickness but was not cured. Next, 1 mm of x-tra fil (VOCO, Germany) composite was applied over it, and then curing was performed for 10 seconds. The rest of the cavity was filled incrementally as explained for group 1.

Group 3: Injectable RMGI (Ionoseal; VOCO, Gemrany) was applied to the gingival floor of the proximal boxes in this group with 1 mm approximate thickness, and cured for 20 seconds. Application of 37% phosphoric acid on the enamel margins, subsequent use of SE Bond primer and bonding agent, and application of composite increments were subsequently performed as explained for group 1.

Group 4: After acid-etching and application of SE Bond primer and bonding agent, a thin layer of x-tra base flowable composite (VOCO, Germany) with 1 mm approximate thickness was applied at the cavity floor and cured for 10 seconds. The rest of the cavity was filled with x-tra fil (VOCO) composite similar to group 1 (control).

Finishing was performed with Sof-Lex™ (3M ESPE) discs in a sequence from coarse to superfine, followed by polishing with interproximal polishing strips and aluminum oxide polishing paste to achieve a smooth and uniform surface, all teeth were stored in distilled water and then underwent thermocycling for 1000 cycles between 5-55°C with a dwell time of 30 seconds and a transfer time of 10 seconds. Next, all teeth were dried, and sticky wax was applied to the root apex after coating the tooth with two layers of nail varnish up to 1 mm from the restoration margins. The wax was slightly warmed and softened before placement to ensure adaptation, and adhesion was verified by gentle tactile testing. for approximately 5–10 seconds under a gentle stream of running water to remove excess surface dye without affecting the dye penetration within the tooth structure.

The teeth were then immersed in 2% Fuchsin for 24 hours, and gently rinsed for 5-10 seconds under water to eliminate the excess dye. They were then mounted in transparent auto-polymerizing acrylic resin and sectioned mesiodistally along the longitudinal tooth axis through the center of restorations. The dye penetration depth was subsequently quantified under a stereomicroscope at x20 magnification by one single operator blinded to the group allocation of specimens, and coded as follows:

Code 0: No dye penetration; Code 1: dye penetration to ½ of the gingival floor, Code 2: dye penetration

[DOI: 10.61882/cofs.3.3.6]

exceeding ½ of the gingival floor, Code 3: dye penetration to the entire gingival floor, and Code 4: dye penetration to axial wall (Figures 2-6).

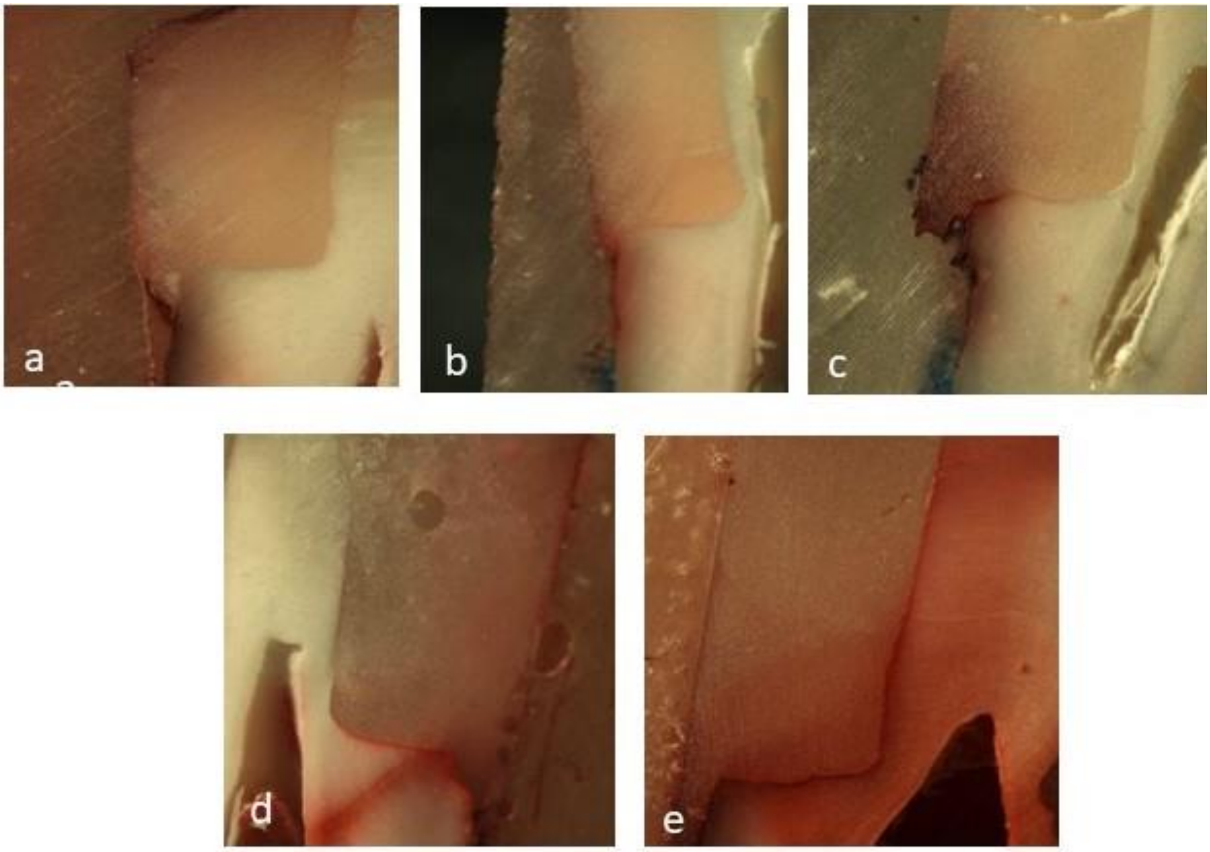

Figure 2. Stereomicroscopic image of a restoration a) with Code 0 microleakage (x20 magnification) b) with Code 1 microleakage (dye penetration to ½ of the gingival floor) (x20 magnification) c) with Code 2 microleakage (dye penetration exceeding ½ of the gingival floor) (x20 magnification) d) Code 3 microleakage (dye penetration to the entire gingival floor) (x20 magnification) e) Stereomicroscopic image of a restoration with Code 4 microleakage (dye penetration to axial wall) (x20 magnification)

The normality of the data was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests, both of which indicated that the data were not normally distributed ($P<0.05$). Therefore, the Kruskal-Wallis test was used for overall group comparisons, and the Mann-Whitney U test was applied for pairwise comparisons, with the significance level set at 0.05.

Results

The mean microleakage (dye penetration score) of the four groups is presented in Table 1. The microleakage was the highest in the snowplow and the lowest in the control group. As shown, the four groups had a significant difference in this regard ($P = 0.001$). Thus, pairwise comparisons were carried out, which showed that the microleakage of the snowplow ($P<0.001$), open sandwich ($P = 0.003$), and flowable composite liner ($P = 0.05$) groups was significantly higher than that of the control group ($P<0.05$). The microleakage of the snowplow technique was also significantly higher than that of the flowable composite liner ($P=0.047$). The difference between the snowplow and sandwich technique ($P=0.149$) and the difference between the flowable composite liner and sandwich technique ($P=0.397$) groups were not significant (Figure 1).

[DOI: 10.61882/cofs.3.3.6]

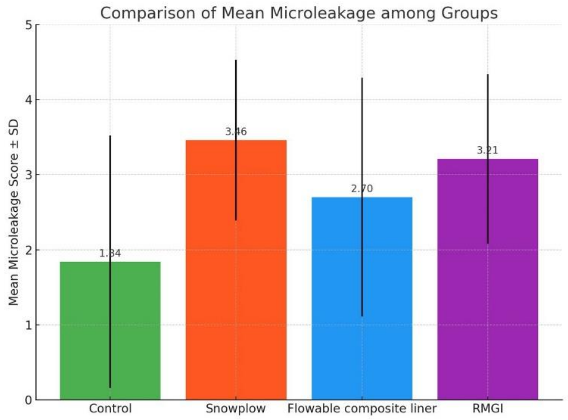

Figure 1. Mean cervical microleakage scores for the four experimental groups

Table 1. Mean microleakage (dye penetration score) of the four groups

Group	N*	Mean ± Std. Deviation	P value
Control	25	1.84 ± 1.68	
Snowplow	28	3.46 ± 1.07	0.001
Flowable composite liner	27	2.70 ± 1.59	
RMGI	28	3.21 ± 1.13	

Note*: N indicates the number of specimens evaluated in each group. Differences in N are due to exclusion of some specimens caused by fracture or damage during preparation, sectioning, or microscopic evaluation.

Discussion

This study compared the snowplow, open sandwich with RMGI, and flowable composite liner techniques for reducing cervical microleakage of posterior Class II composite restorations. Only dentin microleakage was evaluated because it is typically greater than enamel due to lower bond strength and the tubular dentin structure (21–23). Microleakage was highest in the snowplow and lowest in the control group, with significant differences among groups; therefore, the null hypothesis was rejected.

Some authors recommend an elastic layer beneath restorations to absorb stress and reduce microleakage (24,25). Flowable composites have low viscosity and good wettability and are suggested as liners to compensate polymerization shrinkage (17,26), but evidence is inconsistent (27). In this study, x-tra base flowable composite used in both snowplow and pre-cured liner techniques showed higher microleakage than the control, matching previous reports (6,14,16). Their low filler content and high polymerization shrinkage generate stresses that outweigh the benefit of low modulus of elasticity, reducing bond strength and mechanical properties (28,29). Flowable resins are also technique-sensitive; air entrapment can occur during injection (30).

Contradictory findings exist. Bore Gowda et al. (31) reported the lowest microleakage with a flowable liner, possibly due to different composites, application methods, or adhesives. Soubhagya et al. (32) observed gaps between flowable and packable composites, likely from poor adaptation or shrinkage stresses. Bagheridoust et al. (30) hypothesized that simultaneous curing (snowplow) improves adaptation, but both their and our results showed higher microleakage, probably from shrinkage stresses of the high-viscosity composite and increased polymerization stress from greater material volume (33).

RMGI liners also failed to reduce microleakage. In our study the sandwich group ranked second-highest after snowplow, consistent with Moazami et al. (7), Majety and Pujar (35), and Ahmadi Zenouz et al. (27). RMGI can shrink during polymerization, absorb or lose water, and debond from dentin (28,31). Some formulations have two components and are prone to porosity, though injectable RMGI was used here to minimize mixing errors. While Kasraie et al. (6) found improved sealing with a closed sandwich, differences in RMGI consistency, application, or water sorption may explain variable results. Dehydration or voids during injection also increase leakage.

[DOI: 10.61882/cofs.3.3.6]

The control group's lowest microleakage may relate to the self-etch adhesive. Etch-and-rinse systems rely on hybrid layer formation, whereas self-etch adhesives partially demineralize dentin, leaving hydroxyapatite to chemically react with 10-MDP monomers, enhancing bond durability and marginal sealing (32,37,38). Aljamhan et al. (39) similarly reported minimal leakage with SE bonding and bulk-fill composite.

This in-vitro design limits direct clinical extrapolation. Future in-vivo studies with mechanical loading and thermocycling, and evaluation of different flowable composites, modified sandwich techniques, and alternative adhesives, are recommended.

Conclusion

The results indicated that the snowplow, open sandwich with RMGI, and flowable composite liner techniques could not decrease the cervical microleakage, and all resulted in higher microleakage than the control group.

Conflict of Interests:

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial, or non-financial in this article

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[DOI: 10.61882/cofs.3.3.6]