

Cervical Microleakage in Giomer Restorations: An *In Vitro* Study

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ABSTRACT

Aim: The purpose of this *in vitro* study was to determine the effect of different composite placement techniques on gingival microleakage of giomer restorations.

Materials and methods: Sixty class II preparations were created in 30 extracted molar teeth with cervical margins 1 mm below the cemento-enamel junction. The teeth were divided into three groups of 10 teeth each. In group I, teeth were restored with open sandwich technique using Beautifil II and Beautifil II Flow. In group II, teeth were restored with snowplow technique using Beautifil II and Beautifil Flow. In group III, teeth were restored with oblique increment technique using Beautifil II. After thermocycling and immersion in 2% methylene blue, the teeth were sectioned and dye penetration was evaluated.

Results: Statistically significant reduction in microleakage was found along the gingival walls in snowplow restorations compared to sandwich restoration and oblique increment restorations.

Clinical significance: Microleakage was reduced along the gingival walls in snowplow restorations.

Conclusion: Microleakage was significantly lower in the snowplow restorations.

Keywords: Microleakage, Oblique increment restorations, Sandwich restoration and snowplow restorations.

The Journal of Contemporary Dental Practice (2020): 10.5005/jp-journals-10024-2744

INTRODUCTION

Marginal discoloration, secondary caries, restoration failure, and pulpitis are the results of insufficient sealing. Hence, the interface between the restoration and dental hard tissue is an area of clinical concern.¹ One of the weakest aspects of class II composite resin restorations is microleakage at the gingival margin of mesial and distal cavity boxes.

To reduce microleakage, separate incremental insertion modes have been tried. This helped in improving the in-depth curing of composites and minimizing the effect of confinement on contraction stress development.²⁻⁴ Layering method of composite placement has advantages over bulk method of placement of composites. Hence, the small volume of material is used for a lower cavity configuration factor and minimal contact with the opposing cavity walls during polymerization.⁵

A study by Behle mentioned and shared the comparison of the effects of horizontal, oblique, and vertical layering techniques on microtensile bond strength to dentin, and they showed that acceptable bond strengths were observed only when the first increment was bonded horizontally to the cavity floor.⁶

Microleakage involves many factors, such as dimensional changes in materials due to polymerization shrinkage, thermal contraction, absorption of water, mechanical stress, and dimensional changes in tooth structure.⁷

Flowable composites have been recommended as liners beneath composite resins due to their low viscosity and increased elasticity and wettability.

Flowable composite resin was postulated to have the ability to reduce the microleakage. It has been recommended as the first increment for class II restorations because of its better flow, easy application in areas that are difficult to access, and adaptation to irregular surface of the cavity preparation.^{8,9}

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How to cite this article: Patil BS, Kamatagi L, Saojii H, et al. Cervical Microleakage in Giomer Restorations: An *In Vitro* Study. *J Contemp Dent Pract* 2020;21(2):161-165.

Source of support: Nil

Conflict of interest: None

The use of cured increment of flowable resin composite in conjunction with class II resin composite restorations has shown mixed results in microleakage studies.

On the gingival and proximal walls, a flowable resin layer was applied, and this was polymerized with the initial gingival traditional composite layer, which was applied in the cavity. Most of the flowable composite is displaced by the composite resin. Just a small quantity of the composite remained in high-viscosity composite resin areas of the cavity where they did not fully adhere to the cavity walls.^{10,11}

The snowplow technique involves the placement of a layer of flowable composite on the pulpal floor and gingival margin of the proximal box of a posterior composite resin restoration.¹²

In the open sandwich technique, the caries' lesion and class II cavity preparation extend near to or apical to the cemento-enamel junction (CEJ). If the restoration is exposed to the oral environment at the base of the restoration, it is known as open sandwich technique.¹³

In oblique increment technique, the composite resin is placed inside the cavity in many increments. Then one by one the increment is photocured double the time. This was first started through the cavity walls and next to the occlusal surface, so that each increment is in contact only with the bottom and one side wall of the cavity.¹⁴

This study evaluated the effect of snowplow technique, open sandwich technique, and oblique increment technique in reducing the microleakage class II restorations with gingival margins on the root surface.

MATERIALS AND METHODS

Thirty intact extracted molars devoid of caries, restoration, and cracks were chosen for the study. Standardized class II box only cavities were prepared on either of the proximal surfaces with rounded internal line angles and a cavosurface margin at 90° to the tooth surface. The dimensions of the cavities were as follows: buccolingual width = 3 mm, mesiodistal width = 2 mm, and gingival floor = 1 mm below the cemento-enamel junction. The dimensions of the cavities were verified with a periodontal probe. Cavity preparations were performed using a diamond dome-shaped fissure bur and cooled in water a high-speed air turbine handpiece. The bur was replaced after every tenth cavity preparation.

The thirty teeth were divided into three groups ($n = 10$). Around the tooth universal metal matrix band was used, which was externally prepared by applying a low fusing compound that helped to maintain the adaptation of the band to the cavity margins.

Each cavity was cleaned with water spray and air-dried for 5 seconds. The self-etch adhesive is applied to the cavity walls and the air was thinned and cured for 20 seconds.

Group I: Teeth were restored with open sandwich technique using Beautifil II and Beautifil II Flow and cured for 40 seconds.

Group II: Teeth were restored with snowplow technique using Beautifil II and Beautifil II Flow and cured for 40 seconds.

Group III: Teeth were restored with oblique increment procedure using Beautifil II and cured for 40 seconds.

The teeth were stored in distilled water for 1 week, before the cervical margins were finished with fine diamond bur under water cooling and polished with a sof-lex disc. The restored teeth were subjected to 500 thermocycles of between 5°C and 55°C in water baths, with a 30-second dwell time.¹⁵ Apical foramina of the teeth were sealed with sticky wax. Two layers of nail varnish were applied 1 mm away from the cavity margins. Samples were then immersed in a 2% methylene blue solution for 24 hours at 37°C.¹⁵ After which teeth were rinsed with tap water for 5 minutes and then scrubbed to remove the nail varnish. Each tooth was then sectioned mesiodistally with diamond disc, and the extent of microleakage was scored using the international standard organization (ISO) microleakage scoring system. Sectioned restorations were examined under a stereomicroscope (Wild M3C, Heerburg, Switzerland) at 25× magnification. The extent of the cervical microleakage was recorded.

Cervical dye penetration score:¹⁰

Score 0: No dye penetration (Fig. 1A).

Score 1: Dye penetration into ½ of the cervical wall (Fig. 1B)

Score 2: Dye penetration into all the cervical wall (Fig. 1C)

Score 3: Dye penetration into cervical and axial walls (Fig. 1D)

RESULTS

Comparison of open sandwich technique, snowplow restorations, and oblique increment technique with respect to microleakage by Kruskal–Wallis analysis of variance test revealed that $p = 0.0002^*$ which is statistically significant in all three test groups (Table 1 and Fig. 2).

Pair-wise comparison was done using Mann–Whitney test (open sandwich technique vs snowplow technique, $Z = -2.3939$, $p = 0.0166^*$; open sandwich technique vs oblique increment technique, $Z = -1.9746$, $p = 0.04831^*$; and snowplow technique vs oblique increment technique, $Z = -3.6788$, $p = 0.0002^*$) (Table 1 and Fig. 2).

According to the comparison, snowplow restoration showed least microleakage followed by open sandwich restoration which is followed by oblique increment technique.

DISCUSSION

Flowable composites are put forth as liners under class II resin composite restorations due to their low viscosity, elasticity, and wettability.¹⁶ Additionally, thermal expansion of these materials has a coefficient similar to tooth tissue.¹⁷

According to Hooke's law:

Shrinkage stress = shrinkage × modulus of elasticity

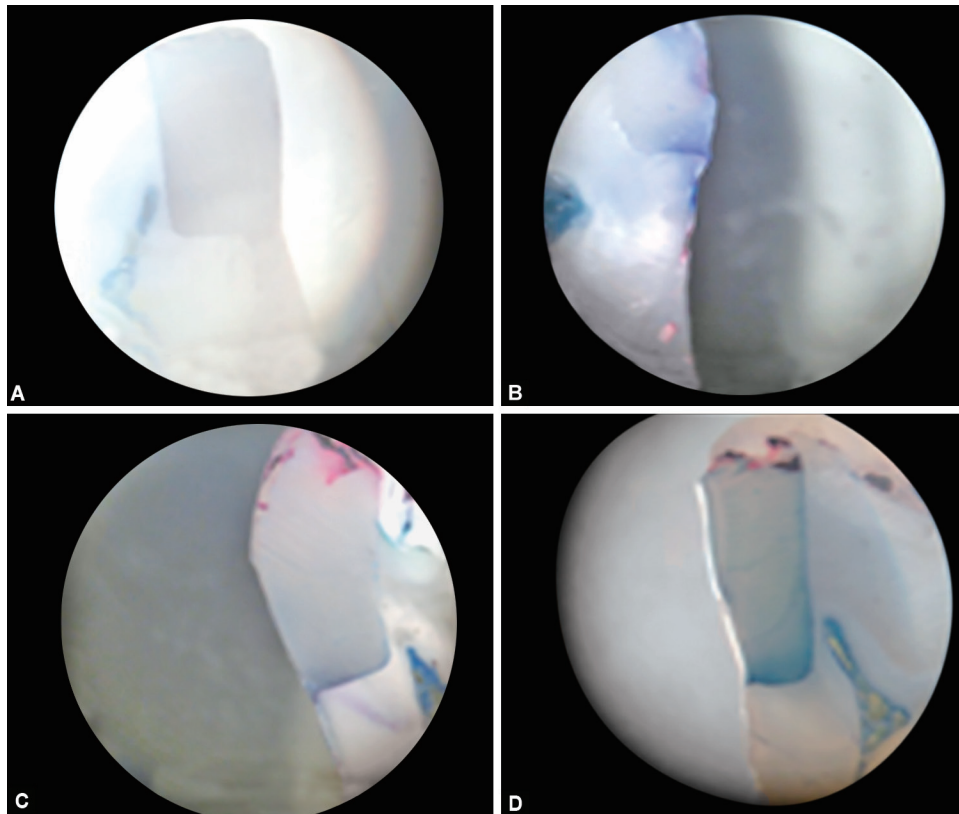
A high modulus of elasticity results in high shrinkage stress during polymerization shrinkage. As a consequence, marginal gap increases. Flowable composite resins exhibit a substantially lower modulus of elasticity that enables increased elastic deformation in which to flex and absorb polymerization shrinkage stresses. This procedure reduces microleakage and stress by 18–50%.^{6,18}

Flowable composites have a coefficient of thermal expansion similar to that of tooth structure. The use of fluid layer may have a low C-factor. The lower the C-factor, the lower the internal stress. When the internal stress is low, there is less competition between contraction forces arising from monomer conversion and the efforts of the adhesive agent to keep the composite bonded to the surface.⁶

Because of higher resin content, flowable composites demonstrate up to three times greater polymerization shrinkage than do standard hybrid composite formulations.^{19,20} Marginal microleakage increased with the increasing thickness of flowable composite lining, which is due to increasing proportion of monomer, resulting in higher polymerization shrinkage value.^{21,22}

This study showed the clinical efficiency of low-viscosity composite resins by reducing marginal cervical microvoids. Second, the low viscosity fluid resin layer helps to improve composite adhesion to the cavity by diminishing the contact angle between the cavity walls and the restoration material, thus reducing superficial strains and stimulating adequate material adjustment to the cavity edges.²³

In snowplow technique, a small amount of flowable composite can be found in such areas of the cavity where the high-viscosity resin composite does not completely adapt to the cavity wall, which may lead to voids. As in this procedure both flowable and



Figs 1A to D: (A) Score 0: no dye penetration; (B) Score 1: dye penetration into ½ of the cervical wall; (C) Score 2: dye penetration into all the cervical wall; (D) Score 3: dye penetration into cervical and axial wall

Table 1: Comparison of open sandwich technique, snowplow restorations, and oblique increment techniques with respect to microleakage by Kruskal–Wallis analysis of variance (ANOVA)

Group	No leakage	%	Half gingival wall	%	Full gingival wall	%	Till axial wall	%	Total
Open sandwich technique	2	10.0	10	50.0	7	35.0	1	5.0	20
Snowplow technique	9	45.0	8	40.0	3	15.0	0	0.0	20
Oblique increment technique	1	5.0	5	25.0	9	45.0	5	25.0	20
Total	12	20.0	23	38.3	19	31.7	6	10.0	60

Kruskal–Wallis ANOVA, $H = 17.1203, p = 0.0002^*$

Pair-wise comparison by Mann–Whitney U test

Open sandwich technique vs snowplow technique, $Z = -2.3939, p = 0.0166^*$

Open sandwich technique vs oblique increment technique, $Z = -1.9746, p = 0.04831^*$

Snowplow technique vs oblique increment technique, $Z = -3.6788, p = 0.0002^*$

restorative composites are co-cured, the remaining flowable composite will absorb the volumetric changes and can stretch or flow to allow stress relaxation.²⁴ On this basis, it is assumed that co-curing of flowable and restorative composites would also result in less polymerization shrinkage and subsequently less microleakage.

The properties of the Beautifil II are closer to the tooth structure and fluoride uptake is from the pre-reacted gioner calcium fillers. This may be explained by the fact that beautibond employs an interesting chemical approach for maximizing the union (mechanic) and bonding (chemical) to tooth substrates. Beautibond contains a monomer of carboxylic acid that promotes bonding to dentin and phosphoric acid to generate bonding to enamel.

Because of higher resin content, the flowable composites demonstrate up to three times greater polymerization shrinkage than do standard hybrid composite formulations.²⁵

This adversely impacts the adhesion of composite to the cavity preparation, as higher polymerization shrinkage and polymerization shrinkage stress have been shown to significantly decrease the bond strength.^{18,26}

As an example, different dye tracers are available for use in microleakage studies. Methylene blue dye 0.5% was chosen as the agent of dye penetration to measure microleakage because it is simple, inexpensive, and does not require the use of complex laboratory equipment. The particle size of this dye is less than the internal diameter of the dentinal tubules (1–4 μm), so it is able to show dentin permeability. Recently, Behle et al. reported that no significant difference was observed in the intratubular penetration between basic fuchsin, silver nitrate, and methylene blue.⁶

Since methylene blue has small surface area (approximately 0.52 nm^2), it may lead to an overestimation of leakage at the tooth–restoration interface, particularly with self-etch adhesives in

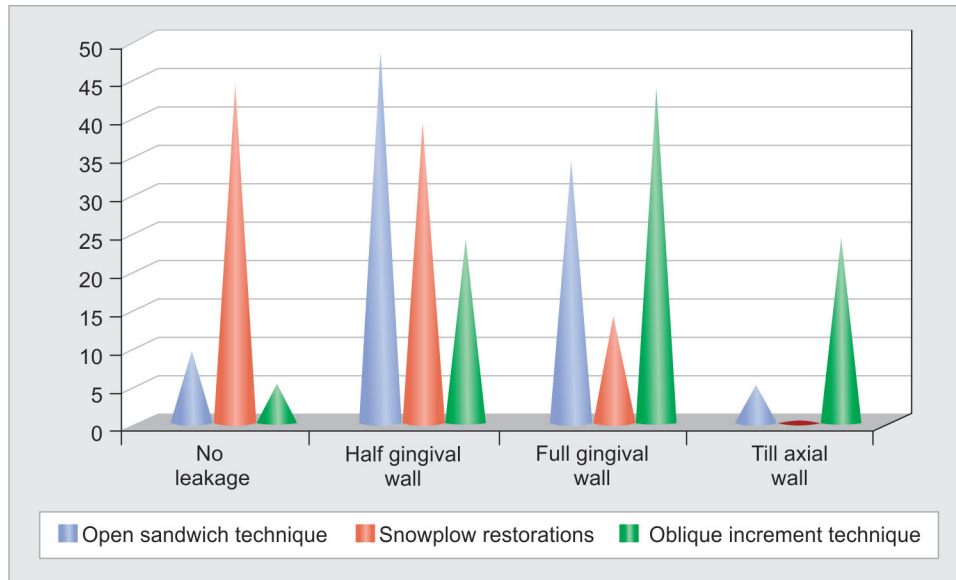


Fig. 2: Comparison of microleakage in all three composite placement techniques

relation to their increased hydrophilicity.²⁷ The use of the methylene blue tracer led to higher microleakage scores compared to other microscopic evaluations.

The water storage and thermocycling samples helps to replicate oral environment. A common artificial aging technique is achieved with the help of thermocycling, which is also a simulation of clinical aging. Some authors reported the absence of any influence of thermocycling on microleakage,²⁸ while others show an increase in microleakage at the cementum–dentin–restoration interface after thermal stress.²⁹

The placement techniques proved to be important for longevity of these materials. Failure associated with these restorations is invariably due to the use of improper technique and microleakage at the gingival margin.

CONCLUSION

Microleakage was clinically significantly lower in snowplow restorations compared to the open sandwich restoration, which has lower microleakage than the oblique increment technique.

Our future scope is snowplow restorations can provide the best marginal seal clinically.

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