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Effect of Placement Techniques on the Marginal Adaptation of Class V Composite Restorations

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Abstract

Statement of the Problem: Several techniques are proposed for the restoration of Class V cavities but there is no agreement in the literature as to which technique is more effective.

Purpose: To evaluate the effect of different techniques of composite increment placement on the marginal adaptation of Class V restorations.

Methods and Materials: Twenty-four human molars were selected and prepared with standardized saucer-shaped cavity dimensions of 3.0 mm (occlusal-gingival), 2.0 mm (mesial-distal), and 2.0 mm (depth). The margins are in reference to the cemento-enamel junction with 1.5 mm being located on enamel and 1.5 mm on dentin. The cavities were randomly assigned into three groups (n=8) and restored with composites as follows: Group 1, the occlusal increment was placed and cured first followed by the gingival increment; Group 2, the gingival increment was placed and cured first followed by the occlusal increment; and Group 3, the cavities were restored with one bulk increment. Restorations were immediately finished and stored for 24 h in tap water. Specimens were subjected to thermocycling (1000 cycles, 5°C to 55°C, 30 s dwell time) and immersed in 0.5% basic fuchsin solution for 24 h in room temperature. After rinsing with running water, the restorations were sectioned longitudinally and enamel and dentin margins were evaluated and scored according to the microleakage on a 0-3 scale. Data were subjected to Kruskal-Wallis test at $p<0.05$.

Results: Median of microleakage scores for all evaluated groups was zero. No statistical difference was observed among the three groups both in enamel ($p = 0.5929$) and dentin ($p = 0.3679$) margins

Conclusion: The placement technique did not influence the marginal adaptation of moderate Class V restorations.

Clinical Significance: No differences on marginal adaptation were observed when restoring conservative Class V cavities using incremental or bulk placement techniques.

Keywords: Marginal adaptation, Class V composite restorations, placement techniques

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Introduction

Access to fluorides, effective preventive programs, and enhanced dental care have increased the opportunity for patients to maintain their natural teeth for a longer time. Root caries and cervical defects have become more prevalent as a result of aging, gingival recession, and dentin exposure.[1-7] Composite resins are the material of choice[1] for restoration of these cavities, this represents a challenge and technically demanding situation because the gingival margin, usually located in the dentin or cementum, is considered a critical factor governing the marginal adaptation.[8-13] Despite their wide use, composite resins still present relevant drawbacks such as the inherent polymerization shrinkage, which results in contraction gaps at the tooth/restoration interface that lead to microleakage.[14-15] Microleakage is characterized by the penetration of acids, enzymes, ions, bacteria, and bacterial products into the margins of the restoration and is responsible for marginal discoloration, postoperative sensitivity, secondary caries, and pulp damage.[16, 17]

Several restorative techniques have been proposed to minimize the polymerization shrinkage consequences and achieve a better marginal adaptation in Class V cavities. Because the bond strength to enamel is usually greater than to the dentin, it was suggested the cavities could be restored in multiple layers, starting with the incremental placement in the occlusal wall of the preparation to minimize leakage of the dentin margin.[18-22] It was also suggested the contraction gap at the gingival margin caused by the polymerization shrinkage could be prevented by the incremental placement of a composite material starting in the dentin portion of the preparation.[2, 9, 10, 23-26] Regarding the bulk placement, it was stated this often results in open dentin margins, thus, increasing the microleakage.[12, 19, 21, 22]

Because there is no agreement in the literature about which restorative technique is more effective, the purpose of this *in vitro* study was to evaluate the effect of three different methods of composite increment placement on the marginal adaptation of conservative Class V restorations.

Materials and Methods

Specimen Preparations

Twenty-four caries-free freshly extracted human third molars were selected and stored for less than 3 months in physiologic solution at room temperature. Standardized saucer-shaped cavities were prepared in each tooth (3.0 mm occlusal-gingival, 3.0 mm mesial/distal, and 2.0 mm depth) on the buccal or lingual surfaces with the occlusal margin located 1.5 mm on enamel from the cemento-enamel junction and the gingival margin located 1.5 mm on dentin by using flame-shaped diamond burs (# 3118, KG Sorensen, SP, Brazil) with a high-speed handpiece under water cooling. Each bur was replaced after four preparations to maintain sharpness. The same calibrated operator prepared all specimens.

Restorative Procedures

The teeth were randomly assigned into 3 groups (n=8). The restorations were placed by a single calibrated operator. In all groups the total-etch technique was performed prior to the application of the adhesive layer. A 35% phosphoric acid (Scothbond Etchant, 3M-ESPE, St. Paul, MN, USA) was applied initially to the enamel margins and then extended from the cavo-surface margins to the floor of the cavity for 15 s. The acid was rinsed away with air/water spray for 15 s and excess moisture was removed with a cotton 'pellet' applied on the dentin while the enamel was gently air dried. In all groups the adhesive system Single Bond (3M-ESPE, St. Paul, MN, USA) was applied according to the manufacturers' instructions and light cured for 10 s. All cavities were restored with a nano-filled composite (Filtek Supreme, 3M-ESPE, St. Paul, MN, USA). The materials used in this study are summarized in Table 1.

The specimens were restored according to the following experimental groups (Table 2 and Figure 1):

For polymerization, a conventional quartz-tungsten halogen light-curing unit (XL 2500, 3M ESPE, St. Paul, MN, USA) calibrated at 500 mW/cm² was used from a distance of 0.5 mm from

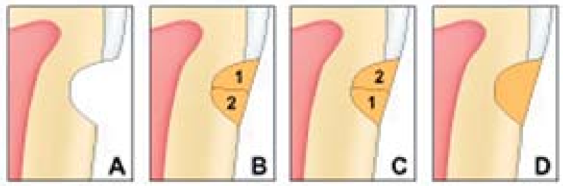

Figure 1. Schematic representation of the experimental design. a) Class V cavity with margins in enamel and dentin; b) enamel increment placed and cured first followed by the dentin increment (Group 1); c) dentin increment was placed and cured first followed by the enamel increment (Group 2); d) Bulk placement (Group 3).

Table 1. Materials, composition, and manufacturers' instructions.

Materials	Composition (Batch Number)	Manufacturers' Instructions
Adhesive system (Single Bond)	1. Scothbond Etchant - 35% Phosphoric Acid, colloidal silica (2BL) 2. Adhesive - HEMA, Bis-GMA, PAA, ethanol and water (2KW)	1. Acid etching (15 s). 2. Rinse (15 s). 3. Blot dry (wet bonding technique). 4. Application of two coats of adhesive. 5. Air dry for 3 s. 6. Light cure for 10 s.
Composite resin (Filtek Supreme) Shade A4B	Organic matrix (bis-GMA, Bis-EMA (6), UDMA and TEGDMA) with zirconia/silica nanocluster and silica nanoparticles) (2AA)	1. ncremental placement (< 2mm). 2. Light cure for 20 s.

Table 2. Restorative procedures.

Groups	Restorative Technique
1	Acid etching + adhesive/light curing (10 s) + occlusal increment/light curing (20 s) + gingival increment/light curing (20 s)
2	Acid etching + adhesive/light curing (10 s) + gingival increment/light curing (20 s) + occlusal increment/light curing (20 s)
3	Acid etching + adhesive/light curing (10 s) + bulk increment/light curing (20 s)

Group1: Cavities were filled with the occlusal (enamel) increment of composite placed and cured first followed by the gingival (dentin) increment.

Group 2: Cavities were filled with the gingival increment of composite placed and cured first followed by the occlusal increment.

Group 3: Cavities were filled with one bulk increment of composite.

its outer surface. Restorations were immediately finished with sequential disks (Sof Lex Pop-On, 3M ESPE, St. Paul, MN, USA).

Assessment Procedure

The restored teeth were stored for 24 h in distilled water. The specimens were then thermocycled (1000 cycles, 5°C to 55°C, 30 s dwell time, transfer time of 3 s). To ensure a reliable thermocycling effect, the water temperature was controlled by the machine's thermostat and monitored with precision thermometers throughout the cycles.

The root apices were sealed with epoxy resin (Araldite, Ciba-Geigy, Basel, SW), and all external surfaces of each specimen were isolated with a layer of sticky wax and two layers of nail polish except for 1.0 mm around the restorations. The teeth were then immersed in 0.5% basic fuchsin solution for 24 h at room temperature. After immersion, the teeth were rinsed with water and sectioned in the middle of the restorations with a low-speed diamond saw under water refrigeration (Isomet, Buehler Ltd, Lake Buff, IL, USA) resulting in two sections for each restoration. The section which was most infiltrated was selected and the respective microleakage score was recorded. The sections were observed under optical microscope at 40x magnification, and the extent of dye penetration was assessed according to a 0 to 3 scale: 0 = no dye penetration; 1 = dye penetration up to 1/3 along the occlusal/gingival wall; 2 = dye penetration up to 2/3 along the occlusal/gingival wall without reaching the axial wall; and 3 = dye penetration reaching the axial wall. The evaluation was performed by two previously calibrated examiners and agreement was forced when disagreements occurred. Data were subjected to Kruskal-Wallis statistical test at a confidence level of 95% ($p<0.05$).

Results

The observed frequency of microleakage scores for each margin and group are presented in Tables 3 and 4. The median of microleakage scores for all groups evaluated was zero.

Discussion

The restoration of cervical defects or Class V cavities is a common procedure in restorative practice. Because the margins are often placed in dentin, dentists continue to seek an ideal technique to restore these defects. Finding a

Table 3. Observed frequency of microleakage scores at enamel margins.

Groups	Total	Median	Frequency of scores							
			0		1		2		3	
			N	%	n	%	N	%	n	%
Group 1	8	0	8	100.0	0	0.0	0	0.0	0	0.0
Group 2	8	0	7	87.5	1	12.5	0	0.0	0	0.0
Group 3	8	0	7	87.5	1	12.5	0	0.0	0	0.0

Table 4. Observed frequency of microleakage scores at dentin margins.

Groups	Total	Median	Frequency of scores							
			0		1		2		3	
			N	%	N	%	N	%	n	%
Group 1	8	0	8	100.0	0	0.0	0	0.0	0	0.0
Group 2	8	0	8	100.0	0	0.0	0	0.0	0	0.0
Group 3	8	0	7	87.5	1	12.5	0	0.0	0	0.0

Group 1: The placement technique, where the enamel portion of the preparation was placed first, provided a complete marginal adaptation for both enamel and dentin margins.

Group 2: The placement technique, where the dentin portion of the preparation was placed first, provided a complete marginal adaptation only at the dentin margins (one specimen showed minimal leakage at the enamel margin).

Group 3: The bulk placement technique did not provide a complete marginal adaptation at either the enamel or the dentin margins even though the microleakage was minimal. However, Kruskal-Wallis test revealed no statistical difference among the three placement techniques both in enamel ($p = 0.5929$) and dentin ($p = 0.3679$) margins.

solution is a challenge because there is some controversy in the literature regarding which technique is the most effective.[5, 6, 26] Composite resins shrink during polymerization, creating contraction stresses that result in marginal gap formation, leading to microleakage.[14, 15] Microleakage can be prevented if the bonding at the interface withstands the stresses generated during polymerization of the composite and function of the restoration, preserving the marginal adaptation. The bond itself depends, among other factors, on the control of placement.[11]

Several placement techniques have been suggested aiming to reduce the shrinkage stresses caused by the polymerization and an enhanced marginal adaptation.[1, 2, 8, 9, 12, 13, 18-26, 28-30] However, the most effective placement technique is unknown.

Within the limitations of laboratory studies, the extension of marginal gaps towards the axial wall in Class V restorations is commonly assessed by microleakage studies.[27] Microleakage tests probably are better for screening and comparative assessment of different techniques than in vitro bond strength tests.[27] However, quantitative marginal analysis by scanning electron microscopy would also be a reliable alternative to determine the quality of the entire adhesive interface.

In this study no microleakage occurred when the occlusal (enamel) portion of the cavity was placed and cured first (Group 1), while only minimal microleakage (not beyond the dentin-enamel junction) occurred at the enamel margin in one specimen of Group 2 restored with the gingival (dentin) portion placed and cured first. When the cavities were restored with a bulk increment (Group 3), minimal microleakage occurred in two margins (one in enamel and one in dentin). There was no significant difference in the microleakage when either an incremental placement technique, starting by the occlusal or the gingival portion of the cavity, or a bulk filling was used.

The results demonstrated, independent of the placement techniques used, the resin-dentin bond was able to withstand the stresses generated by the polymerization shrinkage and thermocycling, resulting in low levels of microleakage. Despite the different amount of microleakage that occurs among studies, probably related to operative and methodological differences, these results are in accordance with other studies that also demonstrated the placement technique did not influence the amount of microleakage.[8, 21, 23, 28-30] However, the present study differs from others studies which demonstrated the incremental placement technique starting at the occlusal increment[12, 18, 19, 24], or starting at the gingival increment[24, 26], or the bulk placement technique[31] results in an improved marginal adaptation.

It should be emphasized the objective of the present study was to evaluate the effect of composite resin placement techniques using currently documented methods and not to assess or compare adhesive or restorative systems. Possibly the use of different materials as well as variations in the cavities' dimensions and designs would lead to different results.

The application of the bulk placement techniques is not indicated for all Class V situations even if the results were not statistically different from those achieved with the incremental placement techniques. This technique should be limited to moderate and small cavities. For larger cavities, the incremental placement technique is recommended, whether it is started by the enamel or the dentin portion of the cavity, because it has been shown to be related to better polymerization, adaptation, and placement control.[32-34]

Although an effort was made to simulate the clinical situation, the results of this *in vitro* study provides only an indication of the clinical performance of placement techniques and should not be extrapolated directly to the clinical environment. Long-term clinical investigations are required.

Conclusion

Within the limits of this study, the method of composite increment placement did not influence the marginal adaptation of moderate Class V composite restorations.

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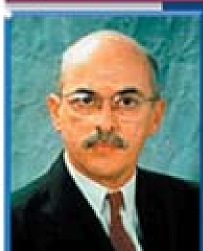

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