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Influence of Resin Composite Shade and Location of the Gingival Margin on the Microleakage of Posterior Restorations

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Clinical Relevance

In terms of marginal sealing, different shades cannot be considered a determining factor for the performance of the resin composite studied.

SUMMARY

Objective: The objective of this *in vitro* study was to evaluate the influence of resin composite shade and location of the gingival margin (enamel or dentin) on the microleakage of proximal restorations on posterior teeth. Methods and Materials: Sixty freshly extracted human third molars were prepared with standardized Class II box-shaped cavities with proportional size and shape, with distal gingival margins located on the enamel and mesial gingival margins on dentin. The teeth were randomly divided into 6 groups according to resin shade (n=10): G1–Incisal; G2–A1; G3–A2; G4–A3; G5–A3.5; G6–A4. The cavities were restored with a total-etch 1-bottle adhesive system and microhybrid resin composites inserted in 4 increments, light cured for 20 seconds through the occlusal surface, then an additional 60 seconds for each surface. After 1 week of immersion in distilled water, the specimens were thermocycled (500 cycles, 5°-55°C, 30 seconds dwell time), sealed with nail polish and immersed in 0.5% basic fuschin solution for 24 hours. The restorations were sectioned longitudinally, and microleakage was evaluated using a 0-3 score scale. Results: Data were subjected to Kruskal-Wallis and Wilcoxon tests at *p*<0.05. No statistically significant differences between groups were observed regarding the shade of resin composite (*p*=0.8570). When margins (enamel or dentin) were considered separately, statistically significant differences were observed between groups (*p*<0.0001), with enamel margins exhibiting lower degrees of microleakage. Conclusion: The variation of resin composite shades utilized in this study did not influence the microleakage of Class II restorations. However, the location of the gingival margin influenced the microleakage.

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INTRODUCTION

Significant advances provided by adhesive systems and improvements in the physical and mechanical properties of resin composites, along with the increasing esthetic demand by patients, have made esthetic direct restorations on the posterior segment a common procedure in the dental practice.

Notwithstanding the concomitant increase in options available and the introduction of modern materials designed to overcome acknowledged deficiencies, the use of resin composite in this situation must be thoroughly analyzed, since having technical resources and materials does not mean that good quality dentistry will be achieved.[1]

However, there are advantages and disadvantages to using resin composites on posterior teeth. The advantages are conservative preparation, esthetics and adhesion to the dental structure.[2-4] The disadvantages are technique sensitivity, polymerization shrinkage, postoperative sensitivity and marginal microleakage.[5] When resin composite is inserted into the cavity, it bonds to the cavitary preparation surfaces through the adhesive system and, during light activation, a competition occurs between the shrinkage force of the composite and bond strength to the dental structure.[6] If the bond strength is weaker than the shrinkage force, this union may fracture, forming a crack, favoring the marginal microleakage, which allows for the passage of bacteria, fluids, molecules or ions between the cavitary surfaces and the restorative material, resulting in failure of the restorative technique.[7]

The literature has shown that major marginal microleakage occurs on the gingival surfaces located in dentin or cement.[8-9] This is because these 2 structures do not offer the same conditions for adhesion to resin composites, of which enamel has better results.[10] In addition, difficulty accessing the proximal boxes of preparations and the control of moisture are complicating factors for the restorative technique.[11-12]

This *in vitro* study evaluated the influence of resin composite shade and location of the gingival margin (enamel or dentin) on the microleakage of Z250 resin composite restorations in posterior teeth.

METHODS AND MATERIALS

Sixty freshly extracted, sound, human third maxillary and mandibular molars were used for this study. After extraction, the teeth were cleaned and stored in physiological saline.

Visual inspection with a magnifying glass was performed to exclude teeth with alterations, which could interfere with the results of this study. The selected teeth were measured with a digital caliper in order to remove a similar volume of dental tissue, both on the mesial and distal surfaces. Consequently, the volume of the restorative material was proportional to the size of each tooth. Dental manikins with joints for the radicular portion through digital pressure were utilized.

To standardize the radicular portion of the selected specimens, an impression was made of the root portion of 1 acrylic tooth from the manikin, using a heavy-bodied polyvinylsiloxane material (Express, 3M ESPE, St Paul, MN, USA). The selected specimen was cut with separating disks; the impression was filled with self-curing acrylic resin, and the tooth's crown was placed on this impression. Then, the natural crown, customized with the "artificial root" was adapted to the manikin.

The teeth were randomly assigned to 6 groups (n=10), and mesial and distal Class II cavity preparations were performed. Cylinder-shaped diamond burs and a high-speed handpiece under air/water spray cooling was used. The diamond burs were replaced every 5 preparations. The cavities were 2 mm axial in depth and 1/3 of the bucco-lingual width, and the gingival margins were placed 1 mm coronal to the dentin-enamel junction (DEJ) in the distal box and 1 mm beyond the DEJ in the mesial box.

The enamel margins were finished with a Weldstaedt chisel. The specimens were then fixed to the manikin and isolated with a rubber dam. The cavities were washed with air/water spray and dried with an air stream. The cavities were etched with a 35% phosphoric acid gel (Scotchbond Etchant Gel, 3M ESPE) initially at the enamel margins, then in dentin for 15 seconds. The cavities were rinsed with oil-free air/water spray for 30 seconds, and the excess moisture was removed with a cotton pellet placed over dentin, while the enamel was gently dried with a slight air stream. Two consecutive layers of a total-etch 1-bottle adhesive system (Single Bond, 3M ESPE) were applied with disposable brushes, according to the manufacturer instructions. A gentle air stream was applied on the adhesive for 2 to 5 seconds, and light-activation was performed for 10 seconds with a QTH light-curing unit (Optilux 501, Demetron Research Corp, Danbury, CT, USA, intensity 700mW/cm^2).

Metallic matrixes were positioned and stabilized with a special clip and wooden wedges. Group 1 restorations were made from a commercially available microhybrid resin composite (Filtek Z250, 3M ESPE) of an Incisal shade.

Insertion was made with an incremental technique (4 increments of 2 mm). The first increment was placed obliquely on the lingual-gingival angle and polymerized for 20 seconds by the occlusal aspect. The second increment was placed on the bucco-gingival angle. The third increment was placed in the area of the contact point. The last increment was placed over the third increment to rebuild the marginal ridge and the occlusal area. Each increment was light activated for 20 seconds with a QTH light-curing unit (Optilux 501, Demetron Research Corp) with an intensity of 700mW/cm^2.

A layer of oxygen inhibitor gel was applied over the restoration margins, and each free surface was subsequently light cured for an additional 60 seconds. The restoration margins were finished with thin and extra-thin diamond burs. For polishing, abrasive disks and strips with decreasing granulation were used (Sof-Lex Pop-On and Sof-Lex finishing strips, 3M ESPE) at the occlusal and proximal surfaces.

For groups 2 through 6, the teeth were prepared and restored in the same manner as for group 1, except for the shades (A1, A2, A3, A3.5 and A4 shades), respectively. After the restorative procedures, the specimens were removed from the manikin and stored in distilled water at room temperature for 1 week.[13-14] The specimens were then separated by groups in nylon bags of different colors and thermocycled (500 cycles, 5° ± 2° to 55° ± 2°C, 30 seconds of dwell time, 3 seconds of transference time).[15-18]

After thermocycling, all the teeth were dried, coated with 2 layers of nail polish (different color for each group), except for 1-mm around the restorations, and immersed in 0.5% basic fuchsine solution for 24 hours at room temperature, rinsed in tap water and dried.[19]

The teeth were sectioned longitudinally with a cutting machine (Isomet 1000, Buehler Ltd) in a mesio-distal direction[17] using a diamond blade (Diamond Wheel 012"x fine, South Bay Technology Inc, San Clemente, CA, USA), under water-cooling at 400 rpm, resulting in 2 sections for the microleakage evaluation of each specimen. The section presenting higher dye penetration was considered for evaluation.[20] The microleakage evaluation was made by 3 previously calibrated examiners using a magnifying glass (10x) under the same conditions (day, hour and light source), based on the following criteria (Figure 1):

0 - No evidence of dye penetration.

1 - Evidence of dye penetration from the margin until half of the gingival wall of the restoration.

2 - Evidence of dye penetration beyond half of the gingival wall of the restoration without reaching the axial wall.

3 - Evidence of dye penetration at the axial wall or towards the pulp.

Readings were recorded on forms and, in the case of disagreements, a consensus was obtained. The results were statistically analyzed by Kruskal-Wallis and Wilcoxon tests (non-parametric Analysis of Variance) with 95% level of confidence.

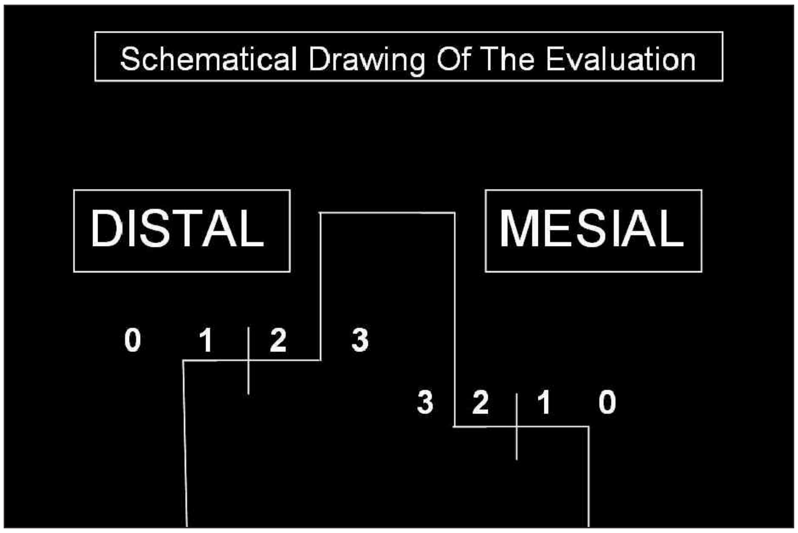

Figure 1: *Schematic drawing of the evaluation.*

RESULTS

The microleakage score was not influenced by the shade of the composite (p=0.8570), nor by separate locations of the gingival margins in enamel (p=0.7074) or in dentin (p=0.4334) (Tables 1 and 2).

To verify whether the location of the gingival margin would influence the marginal microleakage scores, regardless of the resin shade, a comparison between enamel and dentin margins was performed by the Wilcoxon Test (Table 3). The results showed a statistically significant difference (p<0.0001) between them, with the margins in enamel presenting lower marginal microleakage scores than those ending in dentin.

DISCUSSION

Marginal microleakage is one of the major disadvantages of resin composite restorations. It results from failure of the material to adapt to dental structure, usually at the gingival margin. When a layer of resin composite is inserted in the cavity and cured, a competition between shrinkage of the composite and adhesion to the substrate begins. Stresses produced by polymerization shrinkage are critical to adhesion between the resin composite and the tooth structure. This shrinkage stress depends on factors, such as cavity size and shape, substrate type and location of the margins, restorative material and technique of placement and polymerization. If shrinkage stresses are stronger than the bond strength between the resin and adhesive system, the tooth-restoration interface can break, forming a gap that will allow marginal microleakage.[6]

In order to generate tension levels at the interface between the restorative material and the dental structure, the restorations were thermocycled.[21] This method generates "aging" of the restoration through thermal

Table 1: *Scores of Dye Penetration of Groups with Gingival Margins on Enamel*

Group	Total Sample	Scores and Percentage of Dye Penetration for Gingival Margins on Enamel							
		0		1		2		3	
		N	%	N	%	N	%	N	%
Group 1	**10**	**9**	90.0	**1**	10.0	**0**	0.0	**0**	0.0
Group 2	**10**	**8**	80.0	**1**	10.0	**1**	10.0	**0**	0.0
Group 3	**10**	**9**	90.0	**1**	10.0	**0**	0.0	**0**	0.0
Group 4	**10**	**10**	100.0	**0**	0.0	**0**	0.0	**0**	0.0
Group 5	**10**	**8**	80.0	**2**	20.0	**0**	0.0	**0**	0.0
Group 6	**10**	**8**	80.0	**1**	10.0	**0**	0.0	**1**	10.0

Table 2: *Scores of Dye Penetration of Groups with Gingival Margins on Dentin*

Group	Total Sample	Scores and Percentage of Dye Penetration for Gingival Margins on Dentin							
		0		1		2		3	
		N	%	N	%	N	%	N	%
Group 1	**10**	**2**	20.0	**3**	30.0	**0**	0.0	**5**	50.0
Group 2	**10**	**5**	50.0	**0**	0.0	**1**	10.0	**4**	40.0
Group 3	**10**	**5**	50.0	**0**	0.0	**3**	30.0	**2**	20.0
Group 4	**10**	**5**	50.0	**0**	0.0	**0**	0.0	**5**	50.0
Group 5	**10**	**6**	60.0	**2**	20.0	**1**	10.0	**1**	10.0
Group 6	**10**	**4**	40.0	**4**	40.0	**2**	20.0	**0**	0.0

Table 3: *Scores of Dye Penetration by Location of the Gingival Margins*

Group	Total Sample	Scores and Percentage of Dye Penetration by Location of the Gingival Margins							
		0		1		2		3	
		N	%	N	%	N	%	N	%
Enamel	**60**	**52**	86.7	**6**	10.0	**1**	1.70	**1**	1.7
Dentin	**60**	**27**	45.0	**9**	15.0	**7**	11.7	**17**	28.3

oscillations, similar to that which occurs with restorations on clinical conditions, which could have an influential meaning on the microleakage evaluation.[8,18]

Variables, such as cavity size and shape, techniques of placement and polymerization of the composite, were eliminated due to standardization of the study, meaning that only one conventional QTH light-curing unit was used and the resin increments were not larger than 2 mm in order to achieve optimal polymerization.[22-23] Therefore, this study on the influence of resin composite shade and location of the gingival margin on the marginal sealing of direct adhesive restorations, is relevant.

The results show that the marginal microleakage scores were not influenced by the resin composite shade (p=0.8570). This probably occurred because the resin composite shades that were used absorbed a small amount of light, allowing more quantity of incident light to be transferred to the deepest layers, increasing the degree of conversion of the composite. Since each increment was initially light activated for 20 seconds and received an additional 60 seconds of light exposure after the last increment, it is likely that all groups have been cured for a sufficient time, and this has not interfered with their physical properties, which agree with results found in the literature.[22-25] However, other authors found different outcomes as a result of using different shades of resin.[12,26-27] They stated that the size of the filler particles present in the resins influenced the coefficient of light transmission on their interior and depth of cure. However, these authors used microfilled resins, while the current study used microhybrid resins.

No significant differences were observed regarding microleakage of the gingival margins in enamel (p=0.7074) (Table 1) or dentin (p=0.4334) (Table 2). This result can be explained by the fact that the resins acted only as vehicles for the passage of light. In addition, this work suggests that resins behave similarly, since no correlation was found between the resin shade and microleakage scores. Therefore, the amount of dye that differentiates one shade from another cannot be considered a significant issue in the selection of the restorative material to be applied, except for esthetic reasons.

On the other hand, statistically significant differences were observed when the enamel and dentin margins of all groups were compared (Table 3). All groups with dentin margins had inferior results compared to groups with enamel margins ($p<0.0001$). These variations can be explained by structural differences in the substrate. While enamel is basically made from mineral (hydroxyapatite), dentin presents a higher percentage of water and organic material, which makes it difficult to obtain a consistent adhesion capable of resisting the negative effects of polymerization shrinkage and the subsequent thermal and mechanical stresses. There is no adhesive system capable of performing a perfect marginal seal in dentin and enamel.[10,28-30]

CONCLUSIONS

According to the results, it is possible to conclude that:

a) shades of Z250 resin composite did not influence the degree of marginal microleakage in the proximal restorations of posterior teeth, regardless of the location of the gingival margin (enamel or dentin);

b) gingival enamel margins in the proximal cavities of posterior teeth restored with Z250 resin composite presented lower degrees of marginal microleakage than gingival margins in dentin.

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