Comparative Evaluation of Microleakage of Different Class V Cavity Preparation Restored with Composite in Primary Molars: An In Vitro Study

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Abstract:

Objective: To compare the effect of the cavity design and the location of the gingival wall, on enamel and cementum on the microleakage of Class V composite resin restorations in primary molars. **Materials and Methods:** Class V cavity was made on the buccal surface of sixty sound primary mandibular second molar in this study. The teeth were divided into two main groups: Group A (Kidney shaped cavity) and Group B (Rectangle shaped cavity). Each group was also subdivided into two subgroups, Subgroup A_1; Kidney shape with gingival margin on enamel, Subgroup A_2; Kidney shape with gingival margin on cementum, Subgroup B_1; Rectangle shape with gingival margin on enamel and Subgroup B_2; Rectangle shape with gingival margin on cementum. After restoring all cavities with 3M™ Single Bond Universal Adhesive and Filtek™ Z250 XT (3M ESPE) composite, a dye penetration test was performed to evaluate the microleakage of occlusal and gingival margins. **Results:** Regarding the cavity design, a significant difference was found between the rectangle-shaped cavity design (1.1±1.09) and the kidney design (0.733±0.94). Regarding the location of the gingival margin, there was a statically significant difference between margins below the Cemento-enamel junction (2.30±0.98) and those above (1.20±1.13). **Conclusions:** Lowering the surface area of the cavity, as in the Kidney shape, helps greatly in minimizing the microleakage of composite restorations. Moreover, keeping the cervical margin in enamel as possible aids in the reduction of microleakage and saving the marginal integrity.

Introduction:

Composite resins are suitable materials for class V restorations due to their good esthetic results. On the other hand, they may have higher failure rates because of microleakage along the cervical margin.[1] Micro leakage is defined as the penetration of bacteria, fluids, molecules, or ions into the spaces between the cavity walls and the restorative materials, resulting in sensitivity, recurrent caries, discoloration of the restoration margins, irritation of the pulp, and restoration failure.[2]

After a short time of the beginning of the light-curing, viscous flow, limited by the C-factor, is reduced and the resin composite starts to transfer stresses to the cavity walls.[3] So, the cavity shape is considered to be of great importance in conserving the composite-dentin bond.[4] It has not been generally accepted to use CF as a single predictor for shrinkage stresses.[5] Shrinkage stresses and microleakage are probably more dependent on the shape of the cavity.[6] It was confirmed in many researches that the restorative mass must be taken into consideration in clinical recommendations.[7]

Increased tendency of microleakage in large cavity preparations is attributed to reduced strength and greater flexibility of remaining tooth structure teeth and to the greater volume of composite which causes greater shrinkage stresses.[8] By decreasing the bulk amount of resin used, volumetric shrinkage will be less which reduces the stress generated as well as microleakage.[9] It was concluded by Borges et al; 2014, that the positive relationship between the surface area and the stress concentration was firmly confirmed.[10] Also, in Ausiello et al.2021 study decreasing the volume of the resin composite used, had improved the biomechanical behavior of the restoration.[11]

In composite restorations, bonding to different tooth substrates is variable. The absence of enamel at the gingival margin leads to the adhesion of composite materials to cementum/ dentin which is an unstable substrate. Enamel is almost exclusively an inorganic tissue while dentin is less mineralized and contains more moisture which causes variations in adhesion so, a difference may be found between gingival and

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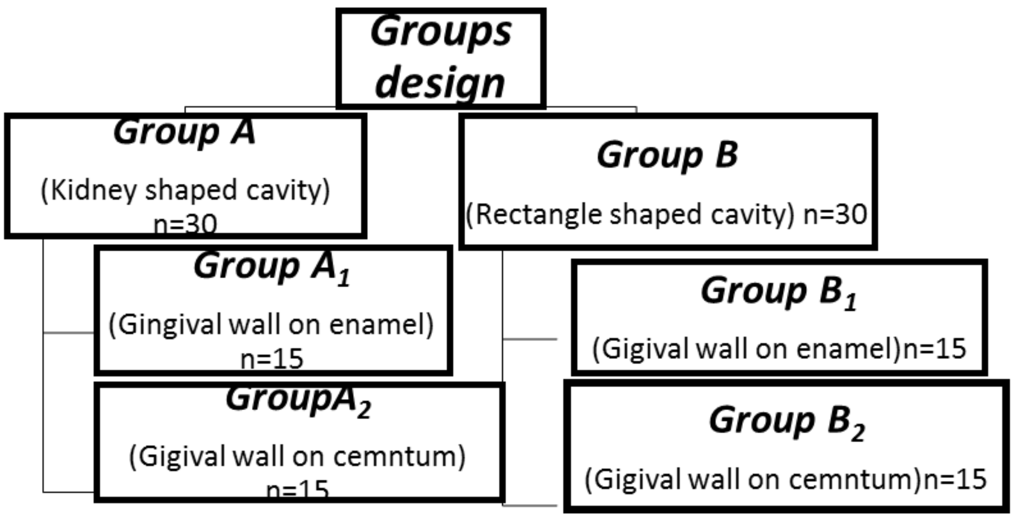
occlusal margins microleakage. [12]
This study was conducted to evaluate the effect of cavity design and the location of the gingival wall, on enamel or cementum on the microleakage of Class V composite resin restorations in primary molars.

Materials & methods:

Teeth Selection and Sample Grouping: Sixty human primary lower second molars recently extracted for therapeutic purposes either about to shed or retained were collected from the clinics of the pediatric Department, Faculty of Dentistry, Mansoura University, according to the protocol approved by the Ethical Committee of Research (Ethics number m12010720). The molars were with intact buccal surfaces and roots that are not fully absorbed. Teeth were stored in distilled water after cleaning all debris with a curette and a soft polishing brush at a low speed. Sample size calculation was based on the depth of dye penetration between studied groups retrieved from previous research (Braga et al., 2006). Using G*power version 3.0.10 to calculate sample size based on effect size of 1.72, 2-tailed test, α error =0.05, and power = 90.0% then the total sample size will be 1 in each group at least. Then, teeth were randomly divided into four groups (n=15):
Cavity Preparation and Restoration: The preparations were cut with a #330 carbide fissure bur in a high-speed handpiece cooled with an air-



water spray. A standardized class V cavity (2.5 mm mesiodistal × 1.5 mm occlusogingival × 1 mm in depth) was prepared at the buccal surface of each tooth. Each bur was used only for five preparations. The standardized dimensions were measured with a periodontal probe to maintain uniformity. Gingival margins, in groups (A_2 and B_2), were just 0.5 mm below the CEJ. The 3M™ Single Bond Universal Adhesive was applied to each group according to the manufacturer's instructions. The adhesive is applied to the prepared tooth and rubbed in for 20 seconds. Then, it was gently air dried for approximately 5 seconds to evaporate the solvent. After that light curing is done for 10 seconds. Filtek Z250 composite resin was applied in two increments; one in the mesial half and one in the distal half of the cavity. The restorations were light cured for 20sec then finished and polished using Elipar S10 light cure.
Dye penetration: Samples were thermo cycled1000 times between water baths held at 5° C and 55°C with a dwell time of 30 seconds and a 10-second transfer time. After thermo cycling, each tooth apex was sealed with utility wax and the teeth were covered with 2 coats of nail polish up to approximately 1 mm of the periphery of each restoration.

Once dry, the teeth were placed in a freshly prepared 1% methylene blue dye solution at room temperature for 24 hours. They were then rinsed in tap water at room temperature for ten minutes to remove the solution and dried. Then, the specimens were sectioned in the bucco-lingually direction from the center of the restoration, and examined under a stereomicroscope with ×40 magnification (Kyowa optical, SDZ-TR-PL, Japan), Figure. The occlusal and gingival margins were qualitatively evaluated separately and scored for dye penetration according to a 0–3 scale scoring system as suggested by Silveira de Ara´ujo et al.[13]
-Score 0—no dye penetration.

-Score 1—penetration involving half or less
The occlusal/gingival wall.
-Score 2-penetration involving more than half
The occlusal/gingival wall.
-Score3-penetration involving up to the axial wall.
Statistical analysis and data interpretation: Data were fed to the computer and analyzed using IBM SPSS Corp. Released2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp. Qualitative data were described using numbers and percentages. Chi-Square test for comparison of 2 or more groups. Testing normality using Shapiro Wilk test. The significance of the obtained results was judged at the (0.05) level. Kruskal Wallis test was used to compare more than 2 independent groups with the Mann-Whitney U test to detect pair-wise comparison.

Results:

Table 1: correlation between occlusal & gingival index among studied groups

	Group A_1	Group A_2	Group B_1	Group B_2
Occlusal & gingival	r=0.11 p=0.562	r=0.456 p=0.01*	r=0.547 p=0.002*	r=0.55 p=0.001*

r: Spearman correlation co-efficient *statistically significant if p<0.05.

In ,Table 1.Spearman correlation coefficient was used to correlate between occlusal & gingival index and illustrates that there is a statistically significant positive correlation between occlusal & gingival indices for group A_2 (r=0.456), B_1 (r=0.547) & B_2 (r=0.559).

Table 2: Comparison of occlusal and gingival scores within groups with the same cavity design

TOTALP	Group A_1	Group A_2	Group B_1	Group B_2
Occlusal	χ^2=15.37 P=0.072		χ^2=6.16 P=0.104	
Gingival	χ^2=8.93 P=0.03*		χ^2=15.52 P=0.001*	

χ^2=Chi-Square test, p: Probability, *statistically significant if p<0.05.

In,Table 2.statistically significant difference was detected between groups A_1 & A_2 regarding gingival score with a higher score for group A_2 than group A_1. Similarly, a highly statistically significant difference was detected between groups B_1 & B_2 regarding gingival scores with a higher score for group B_2 than group B_1.

In,Table3.a statistically significant difference was detected between groups A_1 & B_1 regarding occlusal score and gingival score with higher scores for group B_1 than group A_1. Also, a statistically significant difference was detected between groups A_2 & B_2 regarding occlusal score and gingival score with a worse score for group B_2 than group A_2.

Table 3: Comparison of occlusal and gingival scores within groups with the same location

	Group A_1	Group B_1	Group A_2	Group B_2
Occlusal	χ^2=6.44 P=0.032*		χ^2=2.72 P=0.043*	
Gingival	χ^2=4.59 P=0.024*		χ^2=8.99 P=0.029*	

χ^2=Chi-Square test, p: Probability, *statistically significant if p<0.05.

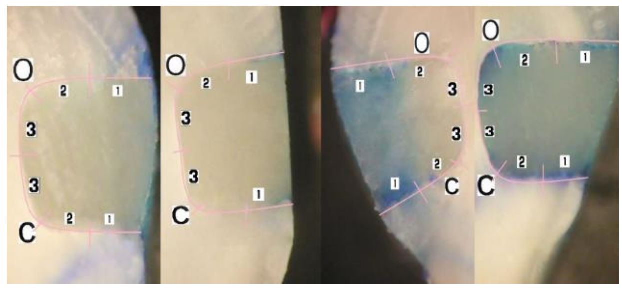


Figure: Samples of stereomicroscope examination showing different scores of dye penetration (O) occlusal margin, and (C) cervical margin.

Discussion:

A "perfect" seal, preventing leakage of contaminants contained in the oral environment, is the main primary objective of any dental restoration.[14] Class V cavities have been a restorative challenge for any restorative material due to their complex morphology where the margins are partly in enamel and partly in cementum and the high tendency of microleakage at gingival margins located below CEJ. Also, evaluation of the sealing ability of composite restorations could be based only on the bonding effect as Class V cavities do not have any macro-mechanical undercuts.[15]

Based on the results of this study, the location of the gingival margin has a significant effect on the microleakage of composite restorations. Comparing groups with the same cavity design (A_1, A_2, and B_1, B_2), there was a statistically significant difference in gingival margin microleakage between groups. Groups A_2 and B_2 (with gingival margin on cementum) yielded a worse score than groups A_1 and B_1 (with gingival margin on enamel) respectively. These results are following previous studies by, Sooraparaju et al; 2014[15] and Gupta et al; 2017.[16]
The outer layer of cementum is hypomineralized and

hyperorganic with no providing of microretention for the adhesive materials.[17] These higher composite microleakage values seen in cervical margins may be related to the lower ability of hybrid layer formation on cementum and can also be attributed to the technique sensitivity of bonding to dentin in comparison with to enamel. [18]C-factor is defined as the ratio between bonded to unbonded surfaces so the C-factor for both Rectangle and kidney shape equals= 5. The volume of the rectangle-shaped cavity can be calculated through the following formula: Volume of a rectangular prism:

$$(V) = (\text{length x width x height})$$
$$V=2.5 \text{ x}1 \text{ x}1.5= 3.75 \text{ mm}^3$$

The volume of the kidney-shaped cavity design can be calculated through the following formula: Volume of kidney = length × width × thickness ×π/6

$$V = 2.5\times1.5\times1\times \pi/6.$$
$$V = 1.96 \text{ mm}^3$$

Regarding the cavity design, our results proved its significant influence on microleakage. Comparing groups with the same gingival margin location (A_1, B_1, and A_2, B_2), there was a statistically significant difference in occlusal and gingival margin microleakage between groups. Groups B_1 and B_2 (with rectangle cavity design) yielded worse scores than groups A_1 and A_2 (with kidney-shaped cavity design) respectively. This finding is following other studies as Borges's 2014[20] study whose results cleared that when the CF was constant, the stress concentrations and microleakage are directly proportional to the volume of the restoration. This is in line with the results of Rodrigues et al 2014[21] and Braga et al study.[22]

Group B_2 represents the worst score among all groups and this is may be attributed to the combination of the two factors (larger cavity volume and gingival margin in cementum). On the other hand, group A_1 represents the least leakage among all groups. This is probably due to the lack of the two affecting factors which worsen the microleakage. This synergetic effect between two factors increasing the microleakage is in line with previous studies as Alomari et al; 2011 study[23] found that the highest scores in dye penetration were only when the two examined factors were combined (fast curing mode was used with high C-factor cavities).

Conclusions:

Lowering the surface area of the cavity, as in the Kidney shape, helps greatly in minimizing the microleakage of composite restorations. Moreover, keeping the cervical margin in enamel as possible aids in the reduction of microleakage and saving the marginal integrity.

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