Original Article

Zahedan Journal of Research in Medical Sciences

Journal homepage: www.zjrms.ir

In vitro Comparison of Microleakage of Nanofilled and Flowable Composites in Restoring Class V Cavities in Primary Molars

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Article information

Article history:
Received: 2 Mar 2012
Accepted:13 Apr 2012
Available online: 15 Oct 2012
ZJRMS 2013; 15(1): 47-51

Keywords:
Microleakage
Flowable Composite
Nanofilled Composite
Primary Molar

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Abstract

Background: Composite resins undergo microleakage due to polymerization shrinkage particularly when located in cementum or dentin. The purpose of this study was to compare the microleakage of flowable and nanofilled composites in Class V cavities extending on to the root in primary molars.

Materials and Methods: Forty eight class V cavities in the cervical part of buccal and lingual surfaces of 24 intact mandibular second primary molars were prepared, with occlusal margins on enamel and gingival margins on cementum. After restoring cavities randomly with nanofilled or flowable composite by incremental technique, specimens were stored in distilled water for 24 hours, thermocycled, immersed in a basic Fuchsin solution for 24 hours and sectioned buccolingually. Microleakage was evaluated according to the depth of dye penetration along the restoration wall using a stereomicroscope. Data were analyzed by Mann- Whitney *U* test at a significance level of 0.05.

Results Microleakage of flowable and nanofilled composites at the cervical margin showed no statistically significant difference, however occlusal margin in nanofilled composite exhibited significantly less microleakage than flowable composite (p=0.013).

Conclusion: In contrast to occlusal margin, there was no statistically significant difference in microleakage between the 2 composites on the gingival margin. Microleakage on the gingival wall was greater compared to occlusal wall for both composites.

Introduction

Restoring primary teeth is very important because these teeth affect the health and the physical growth of children and the timely eruption of permanent teeth. Tooth colored materials which have been widely used in restoring permanent teeth due to advantages such as their beauty, tissue compatibility, lack of mercury, and micromechanical retention, are also commonly used in restoring primary teeth [1].

One of the factors reducing the lifespan of tooth colored materials is the microleakage in the space between the repaired tooth and the material used. This problem mainly results from shrinkage of composite resins during polymerization. This shrinkage can cause the breaking of the bond between the tooth and the repairing material and may create micro-gaps in this space. Specifically, this phenomenon occurs more often in the gingival margin of cavities that end in the enamel or cementum [2, 3]. Various methods and different materials have been developed to reduce these problems. Of course, these materials and methods have often been employed on the dentin or enamel of permanent teeth [3, 4].

Flowable composites were introduced in the 1990s to improve the adaptation of restorative materials to the structure of teeth [5, 6]. These materials have low viscosity and high flow rates [7]. Flowable composites have been commonly used in restoring primary teeth because of their ease of use and due to their suitable initial adaptation to cavities. The high percentage of matrix in the structure of these composites results in greater shrinkage during the polymerization process [8, 9]. On the other hand, the high initial adaptation, greater moisturizing ability, and the low modulus of elasticity of these materials can counteract the effects of shrinkage taking place in the polymerization process [7, 10].

Recently been introduced in nanotechnology as materials with improved clinical results, nanofilled composites have a high percentage of fillers (60% by volume), are comparable with microfilled composites with respect to beauty, and enjoy the same physical features as microhybrid composites. Nanofilled composites do not possess the initial adaptability and moisturizing effect of flowable composites, but they experience less polymerization shrinkage because of the high percentage of filler material content [11, 13].

Al–Razooki et al. compared the microleakage in restorations using nanofilled composites with those in which hybrid and flowable composites were employed. In their study, no substantial differences were observed in the microleakage in the occlusal margin among the materials studied, while the microleakage in the gingival margin of nanofilled composites was significantly greater than those of the other composites [13]. Chimello et al. compared the microleakage of flowable composites with that of hybrid composites in class V restorations. The results they obtained showed that the microleakage in the occlusal and cervical margins in all of the groups of class V restorations was similar, and that none of the restorative materials used could completely seal the gap between the tooth and the material in the gingival margin [2].

In studies conducted on permanent teeth, it has been found that the bond between the tooth and the composite is reliable in cases where the composite is bonded to the enamel, while the sealing feature of resin based materials in cavities extending beyond the cementoenamel junction (CEJ) is uncertain [9]. However, since the structures of the enamel and the dentin of primary teeth are different from those of permanent teeth , and this aspect can influence the micromechanical bonds (and hence the microleakage) [14], and also taking into consideration the advantages and shortcomings of flowable composites (such as their high adaptability to tooth structure and their ease of use in children's dentistry and their high polymerization shrinkage), the comparison of flowable composites with a new type of composites having advantages and shortcomings different from those of flowable composites seemed necessary. Therefore, in this research, the microleakage in the margins of enamel and cementum in the two types of flowable and nanofilled composites used in class V restoratin of primary molars were studied.

Materials and Methods

In this in vitro study, 24 mandibular primary second molars with intact buccal and lingual surfaces in the gingival one-third, and had been extraced for reasons such as root resorption, loss of bone support, etc., were gathered and kept in saline solution, which was changed every week, at room temperature until they were used in the experiment. Before carrying out the different stages of the study, the teeth were placed in chloramine T for 24 hours; their surfaces were then washed with water and pumice powder, and a different code was given to each of them. Subsequently, using a 3 mm cylindrical bur utter, a class V cavity was prepared in the gingival one-third of the buccal surface and another class V cavity in the gingival one-third of the lingual surface of each tooth. The cavities were prepared in such a way that the occlusal margins were in the enamel and the gingival margins in the cementum.

Class V cavities were 3 mm long in the mesiodistal direction, had a 2 mm occlusogingival height, and were 1.5 mm deep. A periodontal probe was used to confirm this depth. After preparing 5 cavities, the bur was changed. Moreover, in order to facilitate the recognition of the lingual surfaces of the cross-sections, a 1 mm deep groove (the guiding groove) was created in the occlusal one-third of the lingual surface and was restored with the composite. After cavity preparation in each tooth, the cavities were etched by 37% phosphoric acid (Meta Nexcomp, Korea) for 15 seconds. The etching solution was applied first on the margin of the enamel and then on the dentin and the cementum; then it was washed with a water spray for 20 seconds and dried for 5 seconds. Subsequently, the dentin bonding (Meta Nexcomp, Korea) was applied and cured for 10 seconds. In half of the number of teeth studied, the buccal cavities were restored using a flowable composite (Nexcomp Flow, Meta Blomea, Korea) and the lingual cavities were restored using a nanofilled composite (Nexcomp, Meta Blomea, Korea), while the flowable composite was used in the lingual cavities and the nanofilled composite in the buccal cavities of the other half of the number of the teeth.

The flowable composite was put in place using a factory-made syringe and the nanofilled composite employing a spatula; the incremental technique was used for placing both composites. According to the directions provided by the manufacturer, each layer of the flowable and the nanofilled composites was cured using the light curing machine (Faraz Dental, Iran). Restorations were then polished and teeth placed in distilled water for 24 hours at room temperature. Next, they were exposed to 1000 thermal cycle of 5–55 degrees centigrade, each cycle with a retention time of 30 seconds and a rest time of 30 seconds.

In the next step, the apex of each tooth was sealed by wax and the surface of each tooth (except for 1 mm around the restoration margin) was covered with two layers of nail polish and was immersed in a 2% basic solution of fuchsin for 24 hours at room temperature. Subsequently, the teeth were taken out of the fuchsin solution, washed with water, and the samples were mounted on transparent acrylic. Finally, buccolingual sections of the teeth were prepared by using a disc (Diamond, Iran). The sections were prepared so that the repaired cavities of the buccal and lingual surfaces, and also the guiding groove created in the lingual surface, could be seen. Two people , who did not know what repair materials had been used on the surfaces of the teeth, used the magnification factor 40 of a stereomicroscope (SZX Olympus, Japan), which had previously been calibrated, to examine the sections and to determine the degree of microleakage on the basis of table 1 [2, 7, 15-18]. Analysis of the data was performed using the statistical software SPSS-17, and the Mann-Whitney U test was used at the level of significance of 0.05 to analyze the data.

Results

On the basis of the statistical analysis of the data, the number of the samples without color diffusion (Score I) in the nanofilled composite was larger than that in the flowable composite and the number of samples with maximum color diffusion (Score IV) was larger in the flowable composite (Fig. 1). According to table 2, on the basis of the higher mean rank of the gingival margins of the cavities restired with the flowable composite, despite the fact that the microleakage of this composite in the gingival margin is greater than that in the occlusal margin, the difference in the frequency of distribution of different types of microleakage in these two margins is not statistically significant. Table 2 also indicates the higher mean rank, and hence the greater microleakage, of the cavities restored with the nanofilled composite. On the basis of the Mann–Whitney U test, and since the *p* is 0.001, we can conclude that the difference between microleakage in the occlusal and gingival margins of the cavities restored with the nanofilld composite is statistically significant.

A comparison of the microleakage of the occlusal margin with respect to the type of restorative material used (Table 3) shows that the mean rank of the flowable composite is higher and that *p* is 0.013; hence, we can conclude that the microleakage in the occlusal margin of cavities filled with the flowable composite is worse than that of the occlusal margin of cavities filled with the nanofilled composite, and that this difference is statistically significant. The mean rank of microleakage in the gingival margin of cavities repaired with the nanofilled composite is higher than that of microleakage in the gingival margin of cavities repaired with the flowable composite, and this difference is not statistically significant.

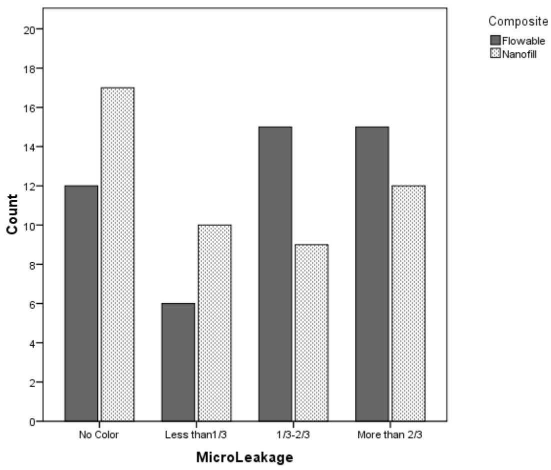

Figure 1. The frequency distribution of the types of microleakage with respect to the types of composites

Table 1. The ranking criterion of color diffusion in this study

The degree of color diffusion	Score
No color diffusion into the occlusal or gingival margins	I
Color diffusion into one-third of the length of the occlusal or gingival margin	II
Color diffusion into one third to two thirds of the length of the occlusal or gingival margin	III
Color diffusion into more than two thirds of the length of the occlusal or gingival margin	IV

Table 2. Comparison of microleakage in cavities restored with flowable and nanofilled composites with respect to the margins (using Mann-Whitney *U* test)

Composite	Margin	Mean rank	95% Confidence interval		*p*-Value
			Upper	Lower	
Flowable	Occlusal	22.28	3.03	2.14	0.402
	Gingival	26.13	3.33	2.25	
Nanofilled	Occlusal	18.27	2.24	1.34	0.001
	Gingival	30.73	3.35	2.40	

Table 3. Comparison of microleakage in the occlusal and gingival margins of the restored cavities with respect to composites (using Mann-Whitney *U* test)

Margin	Composite	Mean rank	95% Confidence interval		*p*-Value
			Upper	Lower	
Occlusal	Flowable	29.29	3.03	2.14	0.013
	Nanofilled	19.71	2.24	1.34	
Gingival	Flowable	24.13	3.33	2.25	0.845
	Nanofilled	24.88	3.35	2.40	

Discussion

This research has revealed that the frequency distributions of different types of microleakage in the occlusal and gingival margins of cavities repaired with the flowable composite are not significantly different, while the differences in microleakage of the two margins in cavities restored with the nanofilled composite are significant. Furthermore, our findings show that the differences in microleakage in the occlusal margins of cavities retored with the flowable or nanofilled composites are significantly different, although these differences are not significant in the gingival margins.

In vitro studies carried out regarding the microleakage of tooth colored materials have provided useful information concerning the sealing behavior of various materials [14, 19]. Numerous factors, including the type of the resin material, the characteristics of the cavities prepared, and the method employed, can influence the microleakage, and hence the success of the restoration [18, 20].

One of the main factors affecting the microleakage of tooth colored materials is the extent of the shrinkage in the polymerization process, which varies from 1.5 to 5 percent. This shrinkage results from changes in the density of the composite at the hardening stage, which is accompanied by the shrinkage of the resin in the direction of the center of the material. This extent of shrinkage in polymerization can bring about internal stress and, may hence cause the separation of the composite from the dental tissue and, finally, lead to microleakage [18, 21]. Factors such as the percentages of the matrix and the filler, and the way the composite is placed in the cavity, influence the extent of the polymerization shrinkage [2].

This in vitro research was also conducted in order to study the microleakage in class V cavities of primary teeth restored with flowable and nanofilled composites. In this study, the microleakage was assessed by investigating the extent of color diffusion at the interface of the material and the dental tissues in cavities similarly prepared and restored by using the two kinds of composites applied through the same processes. In this study the composites used were flowable and nanofilled; the extents of microleakage in the two occlusal (enamel) and gingival (cementum) margins were also investigated.

On the basis of the results obtained from this study, the number of the samples without color diffusion was larger in the nanofilled composite, while there were more samples with maximum color diffusion in the flowable composite. Compared to composites with high filler contents, such as nanofilled composites (with 60% filler materials), flowable composites have less filler materials (30 - 50%) and, hence, possess more matrix. This feature may be a factor for the greater extent of polymerization in flowable composites. Nevertheless, flowable composites, due to their lower modulus of elasticity (1-5 Giga Pascal), can -to some extent- resist polymerization shrinkage and internal stress. On the contrary, composites with higher filler contents undergo less shrinkage at polymerization and create stronger bonds, although they have lower adaptability to dental tissues due to their higher elastic modulus [9, 14, 21].

Studies have shown that the extent of the bonding of the composites to the enamel is far greater than their bonding to the cementum; the reason for this is the greater mineralization of the enamel as compared to the cementum [14]. In the polymerization stage, due to the weaker bonding of the composite to the cementum, the restorative material in the gingival margin is displaced toward the occlusal margin (which is more strongly bonded); and this causes a gap between the material and the structure of the tooth in this area. For this reason, in numerous studies about the microleakage in class V cavities, it has been observed that due to the weaker bonding of the composite to the cementum, leakage is of greater intensity in the gingival margins of these cavities than in the occlusal margins [13, 14].

In our research, the extent of microleakage in the gingival areas of both composites was greater than that in the occlusal areas. Nevertheless, these differences were significant only in the case of the nanofilled composite. Taking the above-mentioned points into consideration, it seems that the greater flexibility and adaptability of the flowable composite in the gingival area has to some extent been able to offset the effect of polymerization shrinkage so that this difference did not become significant. In the research conducted by Al-Razooki et al. to study microleakage of nanofilled, hybrid, and flowable composites used to restore class V cavities in permanent teeth, no substantial differences were observed with respect to microleakage in the occlusal margins, and the intensity of microleakage was greater in the gingival margins of cavities restored with nanofilled composite that than in the gingival margins of cavities restored with flowable composite, but this difference was not significant [13]. In the study conducted on comparing the flowable and the hybrid composites used in restoring class V cavities by Chimello et al., no differences were observed with respect to the intensity of microleakage in the gingival and the occlusal margins [2]. The differences between the results of these studies and those of ours could be attributed to anatomical and histological differences between primary and permanent teeth, because the mineralization of the enamel in primary teeth are lower and irregular than permanent teeth which lead to lower bond of composite to primary teeth [14, 22].

In our study, microleakage in the occlusal margin of the flowable composite was greater than that of the nanofilled composite and this difference was significant. Although the microleakage of the flowable composite in the gingival margin was less than that of the nanofilled composite, this difference was not statistically significant. In the research carried out by Xie et al. which was conducted with the purpose of measuring microleakage in the flowable composite, compomer, and glass ionomer cement used to restore class V cavities in the CEJ area, no significant differences were found in the intensity of microleakage in the occlusal and gingival margins of cavities restored with the flowable composite [7].

Taking the results obtained in our study into consideration, the need is felt for finding composite materials having greater bonding in the areas where the margins of cavities are in the cementum. Since it is not possible to completely reconstruct the clinical situation in laboratories, it appears that carrying out similar clinical research is necessary in which the composites used in our study and also other composites employed in children's dentistry are investigated

Acknowledgements

This article is the result of the approved thesis in the Deputy of Research and Technology of Zahedan University of Medical Sciences with Project No. 2085 and Registration No. 89-1174. We appreciate the deputy for financial assistance. In this study, the role of each of the authors is as follows: study design: Rahil Ahmadi, Nahid Ramazani, and Mohammad Daryaeian, research administration: Saeide Nabavi, article adjustment: Rahil Ahmadi, Nahid Ramazani, and Mohammad Daryaeian. Also, in this study, there is no conflict of interest.

Authors' Contributions

All authors had equal role in design, work, statistical analysis and manuscript writing.

Conflict of Interest

The authors declare no conflict of interest.

Funding/Support

Zahedan University of Medical Sciences.

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Please cite this article as: Ahmadi R, Ramazani N, Daryaeian M, Nabavi S. In vitro comparison of microleakage of nanofilled and flowable composites in restoring class V cavities in primary molars. Zahedan J Res Med Sci (ZJRMS) 2013; 15(1): 47-51.