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Microleakage of Two Composite Resin Materials in Restored Primary Teeth: An In Vitro Study

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Abstract

Objectives: Restoration of primary teeth have become more critical than extracting them. Composite resin materials are considered suitable materials for primary teeth restoration due to their aesthetic and acceptable performance. However, they have limitations such as polymerization shrinkage, microleakage, post-treatment sensitivity, and reduced marginal adaptation. This study evaluated the microleakage of Tokuyama Bulk flow composite and Grandiflow composite resin materials in restored primary teeth.

Methods: In this in vitro study, 54 primary teeth were randomly divided into two groups. After preparing the Class II cavity in the samples and applying acid etch and bonding material, one group was allocated to the Tokuyama Bulk flow composite, and the other group was allocated to the Grandiflow composite. The amount of microleakage was determined by immersion of samples in 1% methylene blue dye and evaluation under stereomicroscope. Scores from 0 to 3 were assigned depending on the degree of dye penetration. Mann-Whitney U test was used to compare the scores in two groups at a significance level of 0.05.

Results: The amount of microleakage in the Grandiflow group was significantly higher than the Tokuyama Bulk flow group (p=0.019). In the Grandiflow group, the highest microleakage score was 3 (63.0%), 2 (29.6%), and 1 (7.4%), respectively. In the Tokuyama Bulk flow group, the highest microleakage scores were 2 (55.6%), 3 (29.6%), 1 (11.1%), and 0 (3.7%), respectively.

Conclusion: It can be concluded that Tokuyama Bulk flow composites have lower microleakage than the Grandiflow composite, potentially affecting the microleakage and subsequent failure of the restoration in a positive way.

Keywords: Deciduous tooth; Composite resins; Dental leakage

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Introduction

Early childhood caries (ECC) is a common caries pattern in children, mainly involving maxillary incisors and first molars.[1] Early caries often progress rapidly and can lead to the destruction of primary teeth.[2] The causes of ECC include high sugar consumption, usually through milk bottles, and poor oral hygiene.[3] These lesions can lead to problems such as decreased chewing efficiency, reduced vertical height of the face, impaired speech, parafunctional habits, and psychological problems. Therefore, it is crucial to preserve deciduous teeth until they exfoliate naturally. Many parents also prefer that their child's teeth be preserved and restored instead of being extracted.[1] Managing deep caries in primary teeth is challenging and depends on patient cooperation, clinician's skill, materials, and costs.[4]

Several treatment options for decayed primary teeth vary from minimally invasive and interventional dentistry to therapeutic approaches. Conservative approaches preserve more of the tooth structure, but it is recommended that cavitated lesions be restored to reduce the caries activity of the lesion. [5] Composite resins are commonly used among tooth-colored materials due to their aesthetic, fracture strength, and wear resistance.[1] Despite composite resins' many advantages, shrinkage stress of its polymerization is a fundamental problem, which can lead to debonding of the composite and enamel bonding surface over time, enamel breakage, post-treatment sensitivity, microleakage, discoloration of the margins, and recurrent caries.[6,7] The main reason for microleakage is improper adaptation between the tooth and the restorative material. [8] Marginal seal, which results from proper contact between the tooth and the restorative material, is critical in reducing microleakage and recurrent caries.[9]

To overcome these problems, the incremental technique is recommended, a gold standard method for the application of composites. However, it has shortcomings, such as the possibility of creating a void, debonding, difficulty placing in small cavities, increasing the operating time, and separate polymerization of each layer.[10] To overcome these problems, bulk-fill composites have been introduced. These composites have the advantage of being used in bulk. They also reduce the duration of treatment, facilitate the healing process, and minimize polymerization stress during curing.[11] These composites can be used in 4 to 6 mm thicknesses. Many bulk-fill composites with different characteristics have been introduced, including formulations with high and low viscosity.[12] Today, one of the initial problems associated with adhesive restorations is the failure to achieve a successful bond to enamel and dentin, and even with good adhesion, microleakage can be seen at the margins of restorations. Microleakage is the passage of bacteria, liquid, molecules, or ions between a cavity wall and the restorative material, which can lead to pain after treatment, discoloration of margins, secondary caries, and pulp inflammation.[13] Marginal seal integrity is essential for a successful adhesive dental restoration.[14] This study aimed to investigate and compare

microleakage in restoring primary teeth using Tokuyama Bulk flow composite and Grandiflow composite.

Methods

This experimental in vitro study was conducted in 2023 at the Faculty of Dentistry, Hamedan University of Medical Sciences, under the institutional ethical code of IR.UMSHA.REC.1402.369. A number of 54 extracted primary teeth (second molars) were examined. The sample size was chosen based on similar previous studies [6] and the formula below:

$$n = \frac{(Z_{\alpha/2}+Z_{\beta})^2 * (p_1(1-p_1)+p_2(1-p_2))}{(p_1-p_2)^2}$$

The samples were randomly selected and divided into two groups of 27 specimens for microleakage evaluation. The randomization method in this study was simple random allocation using a random table. The selected teeth had minimal caries, and the extent of the caries was such that it was possible to prepare a classic class II cavity. After removing caries and undermining enamel by postgraduate student, class II cavities were prepared in all teeth using a diamond bur in a contra-angle handpiece with water coolant. The mesiodistal width of the cavities was 4 mm from the proximal surface of the primary molars, and the cavity's isthmus width was approximately two thirds of the buccolingual width of the tooth. The bur was replaced after preparing every five cavities. The enamel and dentin surfaces of the teeth were etched using 35% phosphoric acid (FGM, Brazil) for 20 and 10 seconds, respectively. Then, the etched surfaces were rinsed for 5 to 10 seconds and dried slowly with air spray. It was noted that the dentin surfaces should not dry too much (wet blotting technique). Two layers of single bond (3M ESPE, St. Paul, MN, USA) were placed on the etched surfaces with a micro brush, and after five seconds, the bonding material was thinned using air spray for five seconds and then cured for ten seconds. The same acid etching and bonding were used in both study groups. The samples in each group received one type of composite resin material:

Group A: Tokuyama Bulk flow composite (PALFIQUE® BULK FLOW; Tokuyama Dental Corporation, Tokyo, Japan) was placed in prepared cavities and cured for 40 seconds.

Group B: Grandiflow composite (Grandi flow; Voco Dental Corporation, Germany) was placed in bulk in prepared cavities and cured for 40 seconds.

After restoration, all specimens were thermo-cycled at a temperature of 5 to 55 degrees Celsius (±2 degrees Celsius) for 200 cycles with a dwell time of 15 seconds and a transfer time of one minute.

All specimens received two layers of nail polish on the entire tooth surface except the restoration and a 2 mm margin of tooth structure around the restoration and were allowed to air dry. All specimens were immersed in 1% methylene blue dye for 24 hours.

After 24 hours, the teeth were rinsed in water. Then, using a diamond disk, the mesiodistal cuts of the teeth were made in two sections. A stereomicroscope (Olympus) with ×10 magnification was used to detect and measure microleakage. The postgraduate student who assessed the scores was unaware of the sample allocation. Scores from 0 to 3 were assigned depending on the degree of dye penetration. The classification of penetration was as follows:

Score 0: no color penetration could be seen.

Score 1: dye penetration was up to half of the cervical wall expansion (Figure 1).

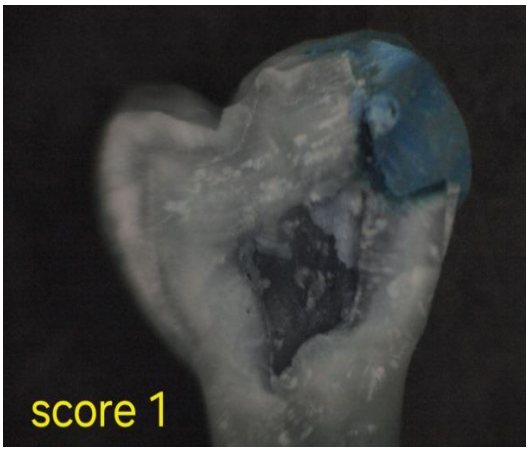

Figure 1: Score 1 for dye penetration in microleakage test, observed under stereomicroscope at a magnification of 10.

Score 2: penetration of color was up to the entire cervical wall (Figure 2).

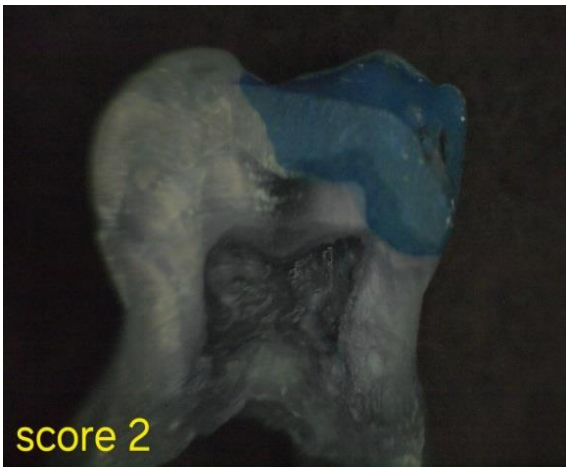

Figure 2: Score 2 for dye penetration in microleakage test, observed under stereomicroscope at a magnification of 10.

Score 3: Penetration of color was up to the cervical and axial walls toward the tooth pulp (Figure 3).

In this study, frequency and score index were used to describe observations. Mann-Whitney U test was used to compare different scores between the two groups. The analysis was conducted using SPSS-16 software at a significance level of 5%.

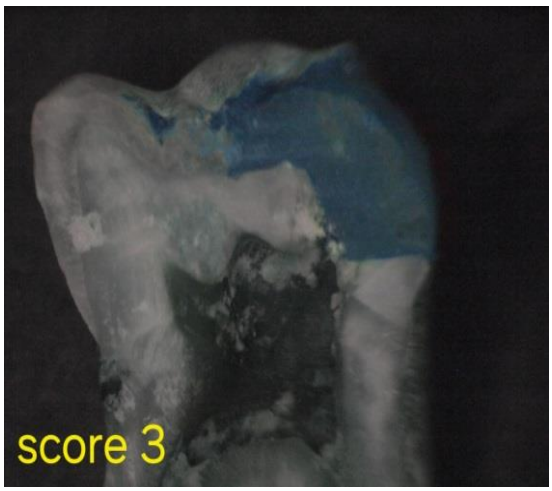

Figure 3: Score 3 for dye penetration in microleakage test, observed under stereomicroscope at a magnification of 10.

Results

The Mann-Whitney U test showed that the mean scores in the two groups were significantly different ($p < 0.05$). In other words, the microleakage rate in the Grandiflow group was significantly higher than that of the Tokuyama Bulk Flow ($p=0.019$).

In the Grandiflow group, the most frequent microleakage score was 3 (63.0%), 2 (29.6%), and 1 (7.4%), respectively. There was no score of 0 in the Grandiflow group, and a score of 3 accounted for the highest percentage. In the Tokuyama Bulk flow group, the most frequent microleakage scores were 2 (55.6%), 3 (29.6%), 1 (11.1%), and 0 (3.7%), respectively.

As seen in Table 1 and Chart 1, the frequency of microleakage with scores of 0, 1, and 2 was higher in the Tokuyama Bulk flow group than in the Grandiflow group. However, microleakage with a score of 3 in the Grandiflow group was more frequent than in the Bulk flow Tokuyama group.

Table 1 - Number and frequency of different microleakage Scores in the two examined groups

			Microleakage Score				Mann-Whitney U test
			0	1	2	3	
Group	Bulk flow (N=27)	n	1	3	15	8	Z=-2.355 P= 0.019
		%	3.7%	11.1%	55.6%	29.6%	
	Grandi flow (N=27)	n	0	2	8	17	
		%	.0%	7.4%	29.6%	63.0%	
Total		n	1	5	23	25	
		%	1.9%	9.3%	42.6%	46.3%	

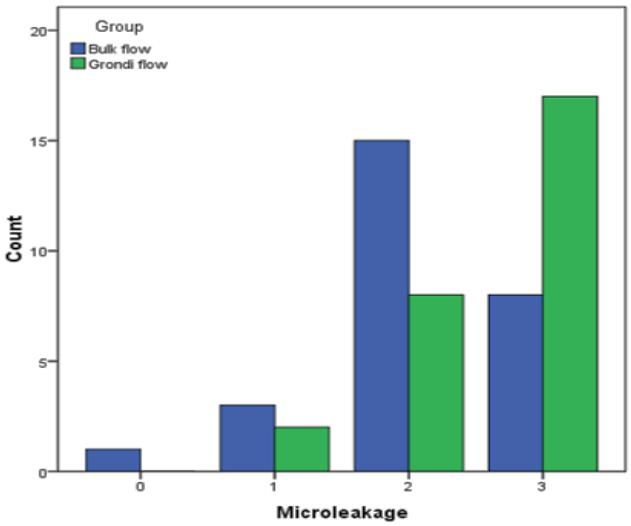

Chart 1: Frequency of different microleakage Scores in the two examined groups

Discussion

Dentists who encounter children with early childhood caries (ECC) are responsible for appropriate restoration of their teeth and maintaining their dental health. Nowadays, the restoration of carious primary teeth is critical to preserve them until they exfoliate naturally, and permanent teeth erupt.[15] According to AAPD policy, dentists who diagnose ECC should either treat the child or refer the child to a trained person for treatment, and immediate intervention is necessary to prevent further destruction of dental tissues. On the other hand, reconstruction of the whole mouth in young children has always been a controversial issue due to children's non-cooperation. Therefore, using methods that reduce the child's treatment time in the clinic is of great value in pediatric dentistry. [16]

Success in restoring primary teeth depends on the material's mechanical properties, such as fracture strength, hardness, wear resistance, and lack of leakage. Bulk-fill composite resins show promising results in restoring primary teeth. Therefore, pediatric dentists may prefer them due to several advantages, such as reduced chair time due to the one-step use of materials, lower risk of contamination during the procedure, and higher child cooperation.[17,18]

Although dental restorations aim to maintain the tooth's remaining structure and protect the dentin and pulp, some restorations deteriorate over time, forming a gap between the tooth and the restoration with microleakage. The absence of

microleakage is necessary for the longevity of the tooth and restoration.[19]

This study compared the microleakage of Tokuyama Bulk flow composite and Grandiflow composite to restore posterior deciduous teeth. The results showed that the microleakage rate in the Grandiflow group was significantly higher than that of the Tokuyama Bulk Flow group.

In this study, similar to Mosharrafian et al.[20], Bulk Flow composites were used for primary teeth restoration. However, they used silver nitrate penetration for microleakage evaluation, but due to the scarcity of silver nitrate, based on the study of Subramaniam and Yeolekar, 1% methylene blue was used in the present study.[7,14]

Most of the previous studies in this area were conducted on permanent teeth. However, according to Güngör's research [21], the amount of microleakage is generally higher in primary teeth, which can be due to the difference in the thickness and structure of primary teeth enamel, which is thinner and contains lower amounts of calcium and phosphorus. The dentin of primary teeth also has thicker tubules than permanent teeth.[22] This issue emphasizes the importance of studying the amount of microleakage in primary teeth, in order to find a way to decrease it.

In this study, a stereomicroscope was used to evaluate the amount of microleakage. Since it was only aimed to check the amount of dye penetration, more advanced devices, such as X-ray spectroscopy were not indicated. Numerous previous studies have employed the identical method to this study.[14,20,23,24]

The present study showed that bulk-fill flow composites have lower microleakage than flowable composites. This aligns with previous research, as AlSagob et al. showed in their study that bulk fill-flow composites have comparable microleakage to conventional composites.[25] Several studies, including Malekafzali et al.'s study [26], have confirmed that conventional composites have a lower microleakage rate than flowable composites.

Scotti has pointed out the benefits of using bulk fill-flow composite in his study, including the marginal adaptation and proper seal, which reduces subsequent problems such as marginal microleakage, margin staining, secondary caries, pain, and sensitivity.[27] The present study's results also recommend using bulk-fill-flow composites.

In one of the most recent studies conducted by Mosharrafian et al.[24], no significant difference was observed between the microleakage rate of bulk-fill composites and conventional composites. Bulk fill composites can be introduced as an alternative to traditional composites due to their advantages, including faster and easier application, which is extremely important in pediatric dentistry. The excellent performance of bulk flow composites, similar to what happened in the present research, can be due to the combination of the advantages of flowable composites and packable composites. They are easily used and placed in the cavity with excellent adaptation, as a result, they reduce future leakage.

Behery et al. showed no significant difference in microleakage of bulk-fill composites in class II restorations compared to conventional composites.[28] Mosharrafian et al. [20], Cayo Rojas [23], and García Marí [29], in separate studies, achieved the same results and suggested the use of bulk-fill composites in children due to the shortening of the chair time. As Park et al. mentioned in their study [30], placing composite incrementally reduces the shrinkage stress compared to putting it in bulk. Also, Ikeda [31] has stated that in 2 mm cavities, highly filled flowable composites show better results if used incrementally instead of bulk placement. Of course, these statements are not in contradiction with the findings of the present study. Because in those previous studies, only conventional composites were used and compared in two ways, incremental and bulk. However, now bulk-fill composites have been introduced that can be cured at a greater depth (4 to 6 mm) and we have used this type of composite in our study in addition to conventional composites.

This study had limitations such as gathering the extracted primary teeth and providing the required composite resin materials. It is suggested that the results be confirmed with more clinical studies. It is also recommended that future studies be conducted on the anterior deciduous teeth, with a more significant number of samples, using other types of composites available in the market, and on the restoration of permanent teeth.

Conclusion

Despite the limitations of this in vitro study, Tokuyama Bulk flow composites showed a lower microleakage than Grandiflow composites in the restoration of decayed primary teeth.

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