Research Paper: Comparing Microleakage Between Bulk-Fill Composites (Flowable, Packable) and Conventional Light-Cured Composite in Class II Cavities

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Abstract

Introduction: Compared to conventional composites, bulk-fill composites increase polymerization depth and contraction stress, and reduce cuspal deflection. Therefore, it is claimed that their microleakage is reduced. This study aimed to compare the microleakage of bulk-fill composites (flowable and packable) with conventional light-cured ones.

Materials and Methods: This in vitro experimental study was done on 60 human extracted premolars. We made standard Class II cavities (4 mm in height, 3 mm in length buccolingually, and 1.5 mm in axial depth) in the teeth. The teeth were randomly divided into three groups based on the type of composite: group I consists of packable bulk-fill (x-tra fill packable; VOCO Company) composite, group II with flowable bulk-fill (x-tra base; VOCO Company), and group III with conventional composite (Grandio; VOCO Company). The total-etch bonding system (the 5th generation) was applied in all cavities. After restoration, the teeth were thermocycled. Finally, the microleakage rate was evaluated using a stereomicroscope. The data were analyzed using the Chi-square test (α=0.05) in SPSS.

Results: The results indicated no statistically significant difference between enamel and dentinal margins in bulk-fill packable and conventional composites (P=0.06). In the bulk-fill flowable group, dentinal margins had greater dye penetration to the enamel margin in the axial surface (P<0.05). There was no significant difference between the three groups in terms of marginal microleakage of enamel and dentin (P=0.05).

Conclusion: Using bulk-fill flowable composites on the dentinal cavity is not suitable with the thickness recommended by the manufacturer. To prove these results, we need to design and perform long-term in vitro and in vivo studies. The use of the incremental technique for placement of composites, even with the bulk-fill group sounds to be more logical.
1. Introduction

Composites were introduced in the 1960s, and since then, much research and developments have increased their application [1]. The search for an ideal esthetic material for tooth restoration has brought about significant improvements in aesthetic features, the techniques of use, and its properties [2]. However, despite the gradual evolution of these resins and their good physical properties, they have some defects; the most important one is contraction due to its polymerization. This phenomenon can cause a gap in the region of bonded composite to teeth surface (especially dentin), and consequently, microleakage, marginal staining, and secondary caries.

Polymerization shrinkage is inevitable, so proper clinical methods should be applied to reduce any possible issues and related risks. This problem can be decreased by various methods such as lowering configuration factor (C-factor), soft start polymerization instead of high irradiance curing, incremental placement, and using a stress inhibitor liner [1]. On the other side, the composite resin manufacturers (often driven by consumers’ demands) are inclined toward producing resins that can be used with quicker and simpler methods by reducing curing time and or using thicker layers of composites [3].

Bulk-fill composite is a new composite resin product that has found popularity among dentists. It has flowable and packable types with specific characteristics. The main progress in this material is its simpler application method and increasing depth of cure due to the reduction of filler content and increasing the size of filler particles, or the change in photoinitiator formulation culminated in higher translucency. Therefore, there is a possibility of adequate light-curing to a thickness of at least 4 mm, which eliminates the need for layering, and is recommended for bulky placement up to 4 mm [3]. The question is, if these composites are used and cured with a thickness of at least 4 mm, will the contraction after their polymerization and the resulting microleakage cause no problem (according to the manufacturer’s claim)?

Many research studies have been done accordingly [4-7]. In various studies, the microleakage in these composites was less than conventional composites, but the results were not significantly different from other study results [4-7]. So, the aim of this in vitro study was to compare the microleakage of available bulk-fill composites, in both packable and flowable types, with a conventional composite. The null hypothesis is that micro-leakage of bulk-fill composites (packable and flowable) does not have any significant difference from that in the conventional composite.

2. Materials and Methods

This study was conducted on 60 healthy human premolars with no caries, crack, or fracture that were extracted due to periodontal reasons or orthodontics treatment plan. The sample size was calculated using PASS II software, considering α=0.05 and β=0.2.

After clearing debris and removing residual tissue tags, the samples were cleaned with a mixture of pumice and distilled water, and then disinfected in 0.1% thymol solution for one week. Next, they were immersed in distilled water at room temperature. By fissure cylindrical diamond bur (No. 008, Tizcavan, Tehran, Iran) under water and air cooling condition, in mesial and distal surfaces of each tooth, an operator prepared Class II cavities with 4 mm in height, 3 mm in buccolingually length, and 1.5 mm in axial depth with parallel walls in a way that occlusal margin was on enamel, cervical margin on dentin, and all margins in butt-joint form (the finishing line was nearly 1 mm below the CEJ line). A new diamond bur was used for every five cavities.

Based on manufacturers’ instruction for all samples, Vocoicid H-Acid (phosphoric acid 37%, VOCO Company, Germany) was applied on dentin and enamel edges for 15 and 30 s, respectively. The surface of the samples was dried off after 10 s washing by blot dry method (with cotton). Then, Solobond M adhesive (VOCO Company, Germany, The 5th generation adhesive) was used for all samples according to manufacturing structure (Table 1). This bonding contains Bis-organic acid, acetone, BHT (butylhydroxytoluene), HEMA (2-hydroxyethyl methacrylate), and Glycidylmethacrylate (GMA). After applying one layer of bonding by micro brush and 30 s pause with slow air spray, the second layer of bonding was placed and cured for 20 s after re-using air spray. For polymerization, we used a light-cure unit (BLUDENT LED smart, Bulgaria) with suitable intensity (800 mW/cm²) that was monitored by light meter unit (Curing Light Meter Model 662).

Afterward, the samples were randomly divided into three groups based on the type of composites (Table 2). After completion of the restoration, the samples were preserved in distilled water at room temperature until the next step. Then, all samples were placed in normal saline at 37°C for one week, and thermocycling was done for each sample at the rate of 1000 cycles with immersion in water with tem-
perature of 50ºC-55ºC (30 s for each cycle and transition time of 10-15 s) (Dorsa, Iran) (Figure 1).

In the following step, the samples were covered with two layers of nail varnish on all tooth surfaces up to a distance of 1 mm from the margin. After that, the samples were immersed in a 0.2% fuchsine solution for 24 hours, then teeth dye was removed, flushed with water, and the teeth were placed in transparent acrylic resin. Mesiodistal and occlusogingival cut were prepared by hard tissue microtome for observing enamel and dentinal margin.

The samples were examined by stereomicroscope (Nikon, America SMZ25) with 25x magnification (Figure 2). The microleakage scoring was done using the method of Rosales-Leal and associates [8]. Scoring for dye penetration was as follows: 0- no dye penetration, 1- dye penetration on no more than half of the axial depth of the cavity, 2- dye penetration not reaching the axial wall, and 3- dye penetration extending to the axial wall.

The obtained data were analyzed in SPSS V. 20 (SPSS Inc. IL, USA). The Chi-square test was used for comparing between microleakage of enamel and dentinal margins. The significant level was set at P<0.05.

### 3. Results

Table 1 presents the microleakage rate of composite restorations in enamel and dentinal margins in all three groups of restorations. Results of the Chi-square test did not show any significant differences between enamel and dentinal margins in the bulk-fill group (P=0.06).

There was a significant difference in the microleakage rate of enamel and dentinal margins in the flowable

<table>
<thead>
<tr>
<th>Groups</th>
<th>Material Brand Name</th>
<th>Composition</th>
<th>Manufacturer</th>
<th>Method of Application</th>
<th>Cure</th>
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<tbody>
<tr>
<td>1</td>
<td>Bulk-fill packable x-tra fill composite</td>
<td>86% mineral fillers in the matrix of methacrylate resin</td>
<td>VOCO Company, Germany</td>
<td>Bulky method: Packed in cavities up to the thickness of 4 mm, polymerized by light cure unit in which its tip was at the closest possible level to the surface of composite</td>
<td>Twenty seconds cure with 800 mW/cm² intensity</td>
</tr>
<tr>
<td>2</td>
<td>Bulk-fill flowable x-tra base composite</td>
<td>75% mineral filler in the matrix of methacrylate resin</td>
<td>VOCO Company, Germany</td>
<td>Bulky method: The procedure of restoration was in a way that the head of the composite injector was located at cavity bottom, and injection was done slowly and moved up in a way that its tip was immersed into the composite to avoid making bubbles. Polymerization was completed after locating the unit tip of light cure at the nearest possible distance to composites: 40 seconds cure with 800 mW/cm² intensity</td>
<td>Cured for 20 seconds, but the last layer for 40 seconds with 800 mW/cm² intensity</td>
</tr>
<tr>
<td>3</td>
<td>Grandio conventional composite</td>
<td>87% mineral filler in the matrix of methacrylate resin</td>
<td>VOCO Company, Germany</td>
<td>Incremental method: One millimeter in the first layer and horizontally 2 mm in other layers. Each layer was separately condensed in the cavity by the condenser</td>
<td>Cured for 20 seconds, but the last layer for 40 seconds with 800 mW/cm² intensity</td>
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(bulk–fill) group (P=0.02), and dentinal margin had more dye penetration. Microleakage did not happen in most of enamel and dentinal margins in conventional group. Results of the Chi-square test did not show any significant difference between two enamel and dentinal margins in the conventional group (P=0.5) (Table 3).

According to the Chi-square test, there was not any significant difference between three groups of bulk-fill (packable or flowable) and conventional composites in terms of microleakage rate in enamel margin (P=0.4) and dentinal margin (P=0.5) (Table 4).

4. Discussion

Nowadays, composite restorations are extensively used in restorative dentistry, and the demand for reconstruction of posterior teeth with tooth-colored restorations is increasing among patient [9]. Therefore, researchers are trying to improve the mechanical and physical properties of these materials to get the best results in mouth environment. Making up composites with new monomers, adding filler particles with different sizes to composite compound, or using different techniques of restoration are all parts of these efforts [10].

Shrinkage due to polymerization is a natural phenomenon in the process of composite curing. This phenom-
enon occurs due to cross-linking between monomers, which cause gap in restoration edges, especially in places where the attachment of restoration with the tooth is not reliable (like dentinal margins). These micro gaps provide the possibility of penetrating saliva and bacteria [11, 12] into the teeth that results in secondary caries, sensitivity after restoration, pulp stimulation, and color change in restored edges [1]. Various methods have been introduced over years to reduce polymerization shrinkage and microleakage in composite restorations. Increasing filler percentage in composite structure, making experimental (lab) composites and adding pre-polymerized resin, application of composite in layer, using of a liner (glass ionomer or flowable composite) on gingival bottom of cavity, using snowplow method in Class II cavities [13], supply of silorane-based composite, and finally introducing bulk-fill composites [14, 15] with high fillers that flows with less polymerization shrinkage are some of these methods. Also, different composite exposure methods can be used in light-cure composites [16]. On the other hand, there are new types of composites named bulk-fill composites (flowable and packable) that have been supplied in the market claimed to have less polymerization shrinkage stress and more depth of cure in comparison with the conventional composites [17].

In the current study, the microleakage of bulk fill composite restorations (flowable, and packable) were assessed and compared with conventional light-cured composites. Similar to other studies, 1000 thermal cycles were done with immersion in water at 5-55ºC with a 30 s duration per cycle and a transition time of 10-15 s per path. This process was per protocol ISO 11450 [18].

The application of acid and bonding cause stronger tooth-restoration bonding and consequently reduce the

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<th>Table 3. Comparing the distribution of microleakage of enamel and dentinal margins in groups using the Chi-square test</th>
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<tr>
<td><strong>Restoration Type</strong></td>
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<td></td>
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<tr>
<td>Packable bulk-fill</td>
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<td>Flowable bulk-fill</td>
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<td>Conventional</td>
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<th>Table 4. Comparing microleakage between three groups in enamel margins using the Chi-square test</th>
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<tr>
<td><strong>Restoration Type</strong></td>
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<tr>
<td>Enamel</td>
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microleakage. In the present study, we used the simplified types of two-step total-etch adhesive, including primer and adhesive, all in one bottle (the 5th generation).

Various methods have studied the microleakage of restoration in the lab. The most simple and practical method is dye penetration [19, 20]. It is believed that in the case of dye penetration under restoration, existing bacteria in the mouth can enter into restoration and cause the side effects of microleakage. However, some researchers believe that microleakage rate in mouth environment is less than rate in the lab [19]. In the current study, fuchsin solution 2% was used which had plenty of applications for studying microleakage based on Moorthy and Fleming studies [3, 21]. In the following, we will discuss our results and compare them with other similar studies.

Based on our results, the null hypothesis was accepted. In other words, there was no significant difference between packable bulk-fill and conventional composites regarding the enamel and dentinal margins (P=0.06). Meanwhile, there was a considerable difference in the microleakage rate of enamel and dentinal margins in flowable bulk-fill group (dentinal margin had more penetration to axial surface than enamel margin) (P=0.02).

Using flowable composite as a liner on the gingival bottom of the cavity is one of the introduced restoration techniques for reducing microleakage [22]. Flowable composites were introduced in the market with a unique chemical structure and claimed to make less polymerization stress [14, 15].

Some researchers argued that flowable bulk-fill composites with fewer polymerization stresses could be used to replace dentin in layers of 4 mm thickness on the cavity bottom. In the study of Juloski et al. it was shown that conventional and bulk-fill composites did not have considerable difference in bond strength to dentin in low shrinkage composites [23]. Moorthy et al. have demonstrated that bulk-fill flowable composites have reduced cuspal deflection compared to conventional composites that used incremental technique and no significant change was observed in cervical microleakage [3]. Cuspal deflections increase microleakage and crack, followed by pain and secondary caries [24].

The study of Al-Ahdal et al. has shown the desirable application of bulk-fill composites in layers with 4 mm thickness, which keeps mechanical properties, acceptable degree of conversion, and lower cuspal deflection [25]. Therefore based on studies of Moorthy et al. and Al-Ahdal et al. microleakage of these types of composites does not have any differences with the other types; also, we can take advantage of bulk-fill flow composites under restoration like cuspal deflection [3]. However, in the current study contrary to the mentioned studies and the other numerous studies which reported bulk-fill composites better (due to their less polymerization shrinkage for microleakage), we observed that dentin microleakage in flowable bulk-fill composites was more than enamel margins.

Different results in our study with the studies mentioned above may be related to the different sample sizes and laboratory conditions. Also, some studies are not like ours in which enamel and dentinal margins have been compared with each other. But there are studies through which similar results can be reached, or they have confirmed our results. For example, Scotti et al. have studied microleakage in enamel and dentinal margins with a bulk-fill flowable composite resin. They reported that dye penetration rate considerably was less for enamel layers compared to dentin (P=0.0001) [6]. The results of Natalia et al. study show that the less thickness of flow composite, the less microleakage happens [26].

Furness et al. stated that the gap between restoration and dentinal axial walls was more than interface walls between restoration and tooth enamel [27]. It means that application of flowable bulk-fill composites on dentin bottom of cavity is not proper and suitable. This finding was contrary to these studies, which reported bulk-fill composites did not have any significant microleakage difference or even they were better. The reason for this problem may be related to low viscosity of these products, and there is a possibility of weak integrity with dentinal bottom of cavity [28].

Based on findings of the current study, in three groups of bulk-fill (packable, flowable) and conventional composites, no significant difference was observed in terms of microleakage rate in enamel and dentinal margins (P>0.05). In the study of Campos et al. no significant difference between bulk-fill composites and conventional ones (with layer technique) regarding the margins’ quality. The current study result is consistent with this finding, and no significant difference between the conventional and bulk-fill composites was observed regarding the microleakage.

In 2014, EI-Damanhoury et al. in a study on stresses of polymerization shrinkage and relevant properties of
bulk-fill composites found that this kind of composites with 4 mm thickness had sufficient curing, but all of these composites were not less contracted and based on microleakage they had similar properties with conventional composites [17]. In 2015, Heintz et al. compared marginal integrity of posterior restoration in bulky method with conventional incremental method and confirmed that margin integrity in Class II cavities with medium size in bulk-fill composite restorations was similar to restorations which were placed in the conventional layers [30]. The results of Natalia et al. study show no significant difference among microleakage of used types of composites in restoration cavities. The applied technique was effective on microleakage, and this effect was different due to the nature of composite [26].

However, some studies like Kumar et al. [5] and Agarwal et al. [4] acknowledged that bulk-fill composites with some of their physical and chemical properties had less microleakage. The reason may be related to urethane presence in bulk-fill composites and or better curing depth [31]. Garcia et al. stated in their study that presence of urethane in the structure of bulk-fill composites by itself regardless of the filler content and the other composite features could control the kinetics of polymerization and reduce shrinkage [32].

Different results in various studies may be related to the different methods for evaluating microleakage and laboratory precision. Also, the differences in the brand of composites used in various studies may be the reason for differences in results. For example, Swapna et al. have evaluated three types of bulk-fill composites (SonicFill Bulk fill, Tetric Evo Ceram Bulk fill, X-tra fill Packable Posterio Bulk fill) and their results showed that microleakage was observed in all types of bulk-fill composites. Besides, there were significant differences in microleakage of occlusal and cervical walls, and occlusal walls have shown less microleakage than cervical walls in all three types of composites. However, SonicFill bulk-fill composite has shown less microleakage in both cervical and occlusal walls [7].

Besides microleakage, the bond strength rate is an important matter. Although there were not any significant differences between the mentioned three groups in terms of microleakage, in the study of Tavangar et al. aimed to compare the shear strength of bulk-fill (flowable, packable) composites with conventional light-cured composites, and with the same materials, the conventional composites showed better results in terms of shear strength [33].

It is also worth noting that further studies are needed to evaluate better conventional and bulk-fill composites and predict their clinical capabilities. Besides, the efficacy of composites in the oral environment and long-term clinical evaluations should be considered [34]. Since the conventional composites compared to the bulk-fill (packable and flowable) composites did not show significant differences in microleakage, we need long-term laboratory studies, and more clinical evaluations should be designed and performed to prove these results. It seems logical to use the layering technique even with the bulk-fill group.

5. Conclusion

Because of the limitations of the current study, the application of bulk-fill flowable composites on the dentinal bottom of cavity is not suitable and proper. Although conventional composites compared to bulk-fill (packable and flowable) composites did not show any significant difference in microleakage, and regarding the result of strength test for bonding and differences in previous studies, we need to design long term in vitro studies and conduct more clinical trials for proving these results. Also, using of incremental method for placing composites even with the bulk-fill group seems more logical.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles were considered in this article. The participants were informed about the purpose of the research and its implementation stages; they were also assured about the confidentiality of their information; Moreover, They were allowed to leave the study whenever they wish, and if desired, the results of the research would be available to them.

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Authors contributions

All authors contributed in preparing this article.

Conflict of interest

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