ORIGINAL PAPER

MARGINAL MICROLEAKAGE EVALUATION OF CLASS II BULK-FILL COMPOSITE RESTORATIONS IN PRIMARY MOLARS – *IN VITRO* STUDY

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ABSTRACT

Introduction: Dental restorative treatments are the most prevalent procedure in dental clinics. Multiple clinical steps are entailed in these treatments especially when using risen composites, which require a properly long chair-time. Bulk-fill composites may be reliable restorative materials for saving time and cooperative behavior with pediatric patients.

Objectives: The aim of this research was to assess a laboratory comparison of the marginal microleakage of bulk-fill and conventional composites in primary molars' class II cavities.

Material and methods: Forty-eight standardized class II cavities were prepared in primary molars and divided into three groups ($n = 16$). Group 1 was restored by conventional composite (Arabesk-Voco) applied via one bulk technique. Group 2 was restored by bulk-fill composite (X-tra fil-Voco) applied also through one bulk technique. Group 3 was incrementally restored by conventional composite (Arabesk-Voco). Phosphoric acid with 37% concentration and bonding agent (Solo bond M-Voco) were used in all specimens. Teeth were sectioned mesiodistally, after having been subjected to 1,500 water cycles and immersed into 0.5% methylene blue to evaluate dye penetration by a four-degree scale. Data was collected and analyzed by SPSS V24.

Results: The three groups did not show complete prevention of dye penetration on the gingival or occlusal margins. No significant difference was observed in terms of dye penetration between the three groups on the gingival margins ($p = 0.534$). Greater occlusal microleakage in the conventional incremental composite group than X-tra fil bulk-fill group was observed. The comparison between the gingival and occlusal margins in each group showed higher leakage on the gingival margins in the bulk filling groups 1 and 2.

Conclusions: There was no significant difference among the groups in terms of gingival microleakage in small class-II cavities in the primary molars. In fact, the application of composite restoration in thin layers on the occlusal section increased the microleakage.

Key words: composite, bulk-fill, pediatric dentistry, primary molars, bulk filling.

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INTRODUCTION

Dental restorative treatments are the most prevalent procedure in dental clinics [1]. These procedures require to use materials with good clinical properties and as simple application steps as possible. Restoring primary teeth can be affected by many factors like age and the child's behavior; thus, a collaborative behavior is necessary to perform a satisfactory restoration in a short time [2].

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Glass ionomer cements (GICs) have been widely used in pediatric patients with high caries risk activity due to their adherence, fluoride release, anti-cariogenic properties, simple application technique, biocompatibility, and low coefficient of thermal expansion [3, 4]. However, the use of GICs is limited for low occlusal stress areas due to their rough surfaces, high porosity, and low mechanical properties [5]. Therefore, other restorative materials such as composites, compomer, and RMGIC can be used instead, when higher mechanical properties are needed [2].

The use of composites in dental restorations has increased in recent years as amalgam use has decreased due to its aesthetic value, mercury toxicity, and the need for retentive preparations. Therefore, resin composite has become a real substitute for amalgam in dental practice for the last three decades [6].

Despite high aesthetic properties of resin composite and the ability to use it in conservative preparations, this material has the property of polymerization shrinkage that causes many post-operative problems such as sensitivity, microleakage, and secondary caries [7]. Moreover, the application of composite restoration is a time-consuming procedure that seems infeasible with an uncooperative child and involves resorting to other restoration materials [8].

Over the past years, a plethora of studies have introduced new materials and techniques in order to reduce the polymerization shrinkage and microleakage of resin composite. These can be exemplified by: flat and oblique incremental filling techniques, the use of flowable lining materials under restorations [9], several light-curing systems, and several modifications of matrix resin [10, 11], or the filler particles [12]. Although the concept of layering technique is the most acceptable among dentists, this cannot exclude the disadvantage of oxygen interference between layers; it is also a very sensitive and time-consuming technique, especially when applying large restorations [13]. In recent years, bulk-fill composites have been introduced with high mechanical properties and ability of application in 5-6 mm layers [12], which can be an adequate alternative material allowing to elude many problems of applying traditional composite restoration, especially with pediatric dental patients [14].

OBJECTIVES

The aim of this study was to evaluate the efficiency of the bulk filling technique using a bulk-fill and conventional composites versus a conventional layering technique in primary teeth class II cavities.

MATERIAL AND METHODS

Approval from the scientific research committee of Damascus University was obtained on Jul 31, 2017 (number /2478/) before the study initiation.

MATERIALS

This laboratory study was conducted on 48 class II cavities prepared in 24-second primary molars and divided into 3 equal groups. Teeth were selected with a crown length of at least 5 mm, free of caries, and calcification defects. The teeth were washed immediately after extraction with running water stream, cleaned from soft tissues, and immersed in 0.5% chloramine-T for one week. Then, they were transferred into distilled water bottles and kept at 4°C with weekly replacement of distilled water until the time of use.

Two standard class II cavities consisted of occlusal and gingival sections were prepared on the mesial and distal sides of each tooth by one calibrated operator, using diamond bur (DIAMANT, Sunshine Diamond, Germany) and high-speed handpiece (NSK, Japan) under water and air spray. The cavity dimensions were: 1.5 mm depth, 2 mm buccolingual width, and 1.5 mm mesiodistal length for the occlusal section. The proximal box was: 3 mm occluso-gingival depth, 3 mm buccolingual width, and 1.5 mm mesiodistal length for the gingival floor (Figure 1). The teeth were randomly divided into three groups (n = 16), following the filling material and technique. Table 1 shows the restoring materials used in this study.

METHODS

All cavities were rinsed, dried, and acid-etched by 37% phosphoric acid (META, Korea). The etchant was applied for 15 seconds on the enamel margins and was then applied for 15 seconds on dentine, rinsed with air and water spray for 10 seconds, and dried with cotton pellet. The bonding agent (Solo bond M, Voco, Germany) was subsequently applied, lite air-sprayed for 3-5 seconds, and cured by an LED light curing unit (Woodpecker, Shanghai, China) for 20 seconds. A metal matrix was applied, and cavities were restored by one operator as the following. In the group 1, the cavities were restored by bulk filling using conventional composite (Arabesk, Voco, Germany) and cured for 20 seconds from the occlusal surface. The matrix was removed, and the restoration was then cured for 20 seconds from the buccal and lingual surfaces. The restoration was polished by soft burs. However, in group 2, the restoring technique was similar to the first group, but the bulk-fill composite (X-tra fil, Voco, Germany) was used in this group. Finally, in group 3, Arabesk conventional composite (Voco, Germany) was applied incrementally in 5 layers and cured for 20 seconds for each layer occlusally. The restoration was cured for another 20 seconds from buccal and lingual surfaces and polished after matrix removal (Figure 1).

Teeth were then subjected to 1,500 water cycles in distilled water between 5-55 ± 4°C for one-minute dwell-

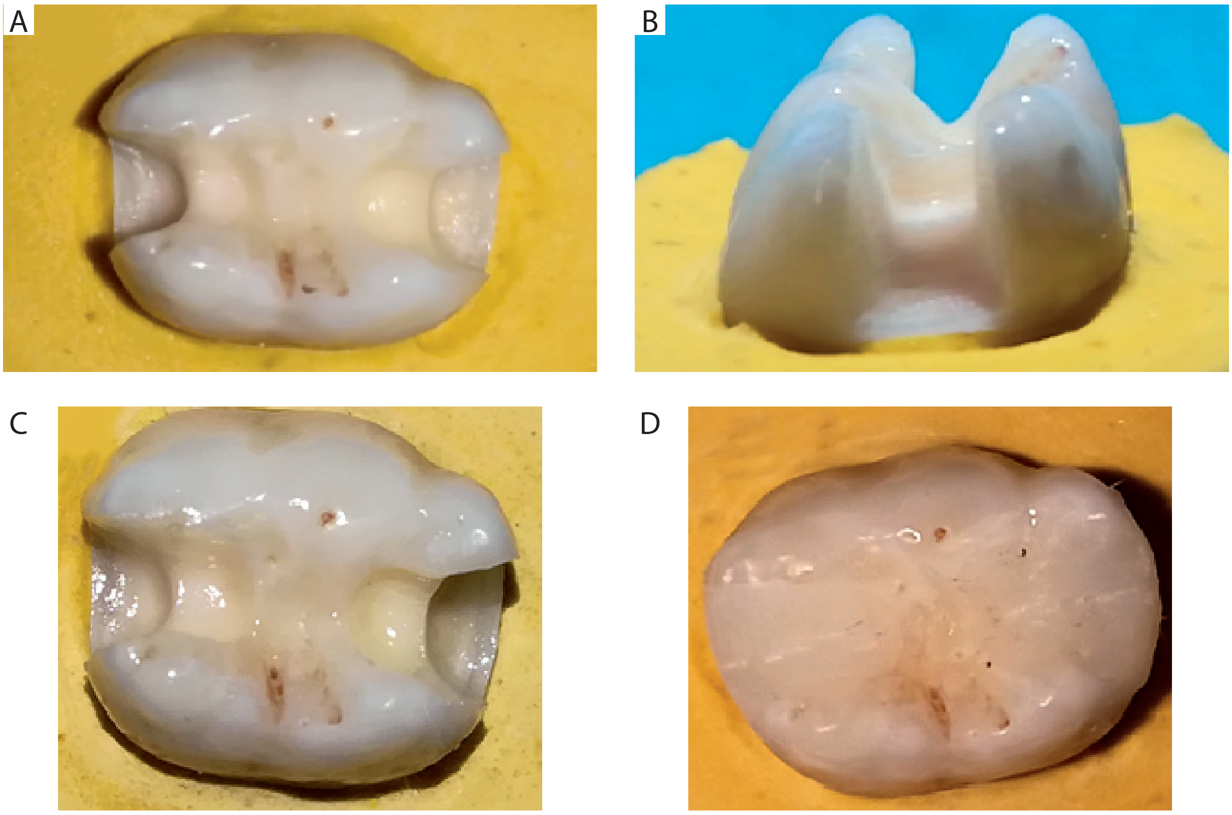

FIGURE 1. The class II preparation, occlusal **(A)**, and lateral **(B)** aspects; **(C)** before composite application, **(D)** restoration after finishing and polishing

TABLE 1. Materials used in this study

Material	Description	Properties	Manufacturer
Arabesk	Universal light-curing micro-hybrid dental composite	Methacrylate matrix (Bis-GMA, UDMA, TEGDMA, BHT, HEMA); contains 60% by volume inorganic fillers	VOCO, Cuxhaven, Germany
X-tra fil	Light-curing hybrid bulk-fill composite	Methacrylate matrix (Bis-GMA, UDMA, TEGDMA); contains 70.1% by volume inorganic fillers	VOCO, Cuxhaven, Germany
Solo bond M	Two-step etch-and-rinse light-curing adhesive system		VOCO, Cuxhaven, Germany
Meta Etchant	37% of phosphoric acid gel		Meta Biomed, Korea

time and transfer time of 5 seconds [15]. The tooth apices and internal roots surfaces were sealed with luting wax. Three layers of nail varnish were applied on the tooth surfaces to the level of 1 mm around the restoration margins. Teeth were immersed in a 0.5% methylene blue solution for 4 hours, then washed with running water, and dried. Each tooth was placed vertically in a plastic mold and immersed with acrylic resin. A mesiodistal section level was marked on the acrylic blocks, then the block with tooth inside was sectioned with high-speed diamond disc under spray water cooling. Each section was evaluated under x 10 magnification with a dental microscope (Smart Optic, Seliga, Polska), and digitally photographed using a camera (Sony, ILCE-6000L, Japan).

Dye penetration was determined on the gingival and occlusal margins by two blinded operators (post-graduates of dental school) using a four-scaled scoring system: 0 – no dye penetration; 1 – dye penetration is limited before DEJ (dentino-enamel junction); 2 – dye penetration exceeds DEJ without reaching the pulpal wall; and 3 – dye penetration reaches the pulpal wall (Figure 2). Data were collected and analyzed using SPSS V24. Kappa coefficient was utilized to evaluate the compatibility between the two operators' readings of dye penetration degrees; the results exhibited good consistency ($p = 0.001$). The microleakage degrees were compared throughout the three groups using Kruskal-Wallis test. Mann-Whitney test was used to compare the microleakage degrees of the gingival and occlusal margins in each group.

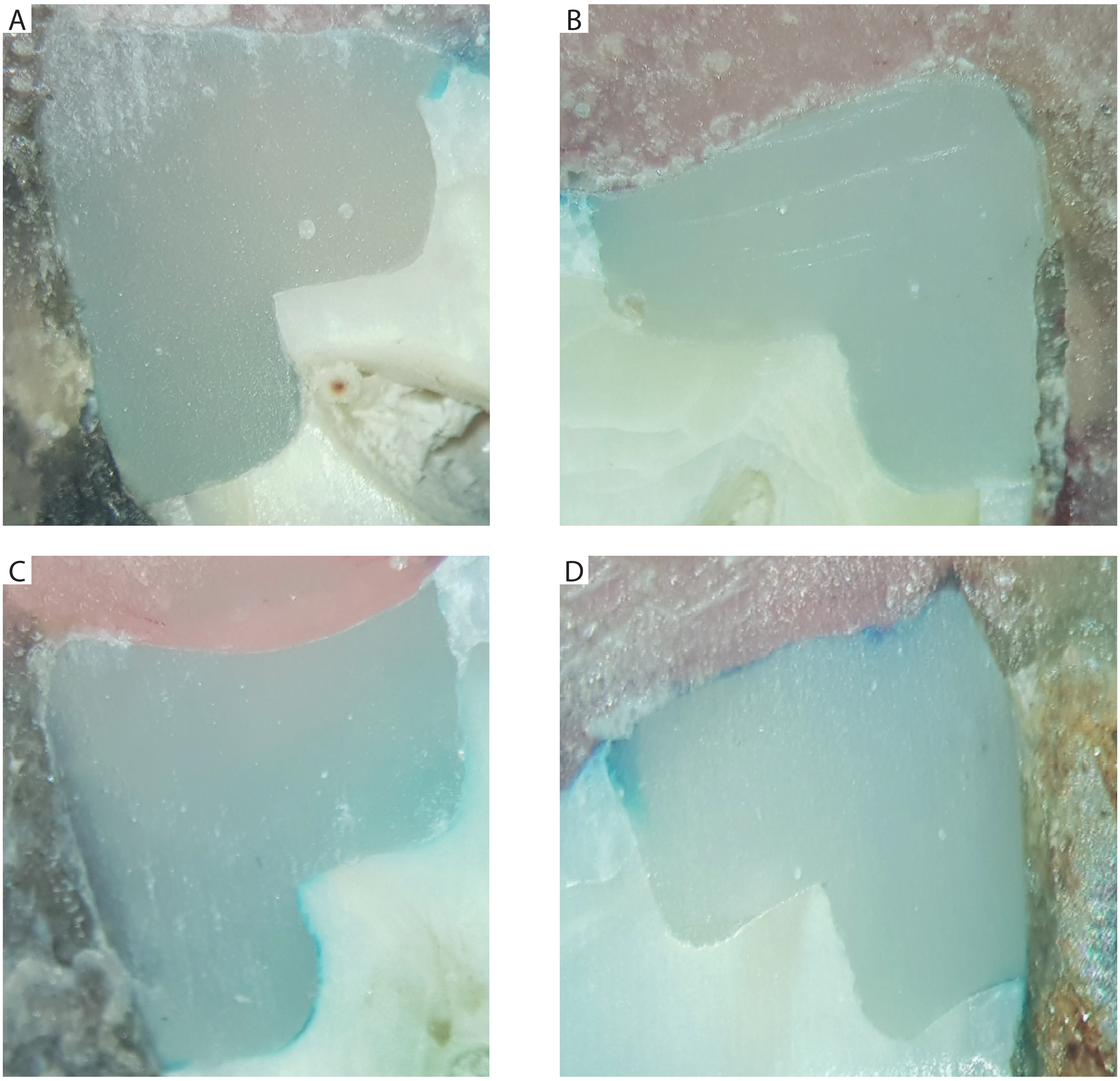

FIGURE 2. Photographs of sections under 10 × magnification. Dye penetration scores are in section **A:** 0 – gingival, 1 – occlusal; section **B:** 0 – gingival, 1 – occlusal; section **C:** 3 – gingival, 3 – occlusal; section **D:** 1 – gingival, 1 – occlusal

RESULTS

None of the three groups was able to show a complete prevention of dye penetration neither on the gingival nor the occlusal margins; besides, the microleakage scores ranged between 0 and 3 in all groups (Figure 3**)**. The comparison between the three groups using Kruskal-Wallis test demonstrated statistical differences in microleakage in the occlusal margins ($p = 0.046$), but the gingival microleakage was not statistically different ($p = 0.534$), as shown in Table 2. The binary comparisons for the occlusal microleakage were operationalized using Mann-Whitney test (Table 3), and the results showed a significantly higher microleakage in group 3 (Arabesk layering) than in group 2 (X-tra fil bulk). This result is graphically presented in Figure 4. Mann-Whitney test was used to compare the microleakage between the gingival and occlusal margins in each group. The results revealed a significantly higher gingival microleakage than the occlusal in groups 1 and 2, as demonstrated in Figure 5.

DISCUSSION

The aim of this study was to determine whether the bulk-fill composite could perform better in terms of marginal microleakage than the conventional composite, when used in incremental and bulk technique in small class II cavities in primary teeth. In group 1, the conventional composite was applied in one increment to determine if this procedure could make an observed difference than the incremental technique in a small cavity. The second primary molars were selected for this study because of their large size, which can hold a large class II preparation. Thermal cycles were applied

TABLE 2. Kruskal-Wallis result for gingival and occlusal microleakage

Margin	Composite	Mean ranks	*p* value
Occlusal	Arabesk bulk	23.56	0.046
	X-tra fil	20.44	
	Arabesk incremental	31.72	
Gingival	Arabesk bulk	26	0.534
	X-tra fil	27.88	
	Arabesk incremental	22.94	

TABLE 3. Binary comparison for occlusal dye penetration

Composite	Samples	Mean ranks	*p* value
Arabesk bulk	16	14.53	0.102
Arabesk incremental	16	20.14	
Arabesk bulk	16	17.53	0.498
X-tra fil	16	15.47	
Arabesk incremental	16	21.08	0.019
X-tra fil	16	13.47	

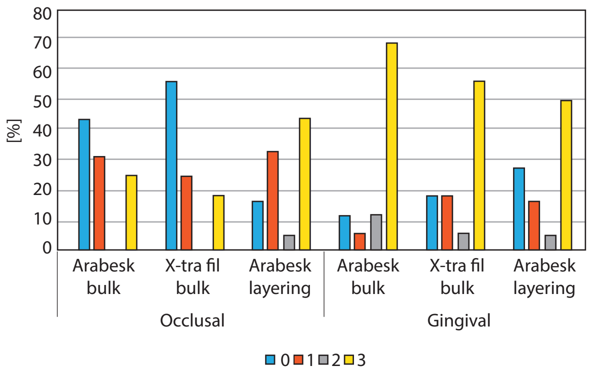

FIGURE 3. Marginal microleakage degrees distribution in the three studied groups

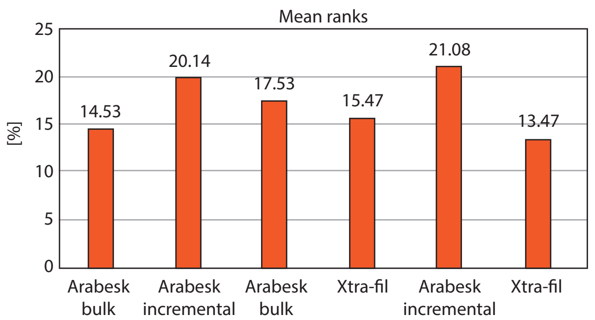

FIGURE 4. Occlusal microleakage comparison for each two groups

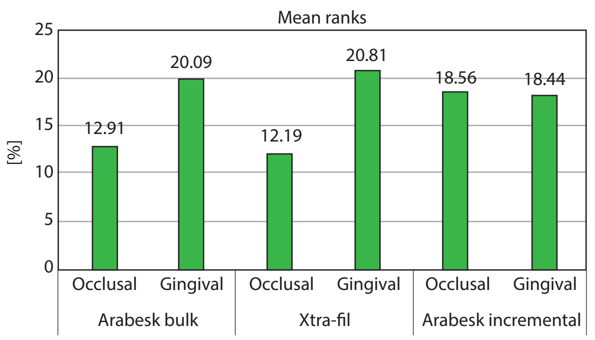

FIGURE 5. Dye penetration differences between gingival and occlusal margins in each group

on the restored teeth in order to mimic the frequent temperature changes in the oral cavity, which has been adopted in many studies [16-19]. Microleakage assessment was carried out in this research as one of the traditional methods for determining adverse effects of polymerization shrinkage of dental composites [20]. The dye penetration method was used to evaluate the marginal microleakage, which is the most common method in laboratory studies. It is a simple, non-toxic, and detectable method at low concentrations that enables comparison of results as well as its low cost compared to other techniques [21].

The layering technique in group 3 has revealed the lowest gingival microleakage compared to the bulk technique in the other two groups. This result may be attributed to the light curing of each thin composite layer separately, which may lead to a better polymerization in deep layers in comparison to the bulk-filled restorations. However, gingival microleakage was not statistically different between the three groups, and this can be explained due to the little depth of gingival floor (3 mm occluso-gingival) that allows a good penetration of the curing light from occlusal, buccal, and lingual sides.

Behery *et al.* [22], in 2018, evaluated the gingival microleakage of three types of bulk-fill composites compared to a conventional composite in class II cavities using procion red dye solution, and found no significant difference between the four groups. Their findings are compatible with ours, although some differences existed between the two studies such as the dye solution and bonding agent used as well as the gingival margin, which was placed at 0.5 mm below CEJ (cemento-enamel junction) in their study. Habib *et al.* [23] investigated the gingival microleakage of bulk-fill and conventional composites in premolars class II cavities. They found less microleakage while using Filtek bulk-fill, 3M, with no significant statistical difference between the examined groups. This result corresponds to our study's results; however, the highest score of microleakage had been degree (1) in their study, with the degree (3) in our study. The difference can be referred to better bonding strength with permanent teeth [24] and lower viscosity of Filtek bulk-fill (fillers 58.4 vol. %), which gives better sealing ability. Moorthy *et al.* [25] tested the cuspal deflection and microleakage of two flowable bulk-fill composites compared to a conventional composite and resulted in a less cuspal flexure with flowable bulk-fill composites. Nevertheless, the cervical microleakage was not statistically different between their three investigated groups. This result comes in accordance with our findings in terms of gingival microleakage.

Concerning the bulk-fill technique that was used in groups 1 and 2, the results of gingival and occlusal microleakage were comparable irrespective of composite material used. This might refer to the resemblance in polymerization shrinkage between the two materials (Arabesk and X-tra fil), particularly in small bulks. Our results come in accordance with findings from Sunbul *et al.* study [26], since they found a comparable polymerization shrinkage results between traditional and Bulk fill composites.

The occlusal microleakage was the highest in the third group (layering technique), which may be ascribed to the cavity design (shallow occlusal extension of 1.5 mm) used in this study (Figure 1), and a possible lack of composite consistency when applied as three thin layers. Even so, the difference in the occlusal microleakage was not statistically significant between groups 1 and 3, which was due to restoration by the same material (Arabesk) in those groups, regardless of the filling technique.

Misilli and Yilmaz [27], in 2018, evaluated the microleakage of a conventional composite employing three types of incremental technique and the bulk technique in class II restorations. No significant differences between studied groups, neither on gingival nor occlusal margins, were observed. These findings are in the line with our investigated groups 1 and 3, which can be referred to low thickness of preparations (1.5 mm) in occlusal and proximal surfaces that allowed a sufficient light cure penetration and polymerization.

In the primary teeth, Mosharrafian *et al.* [18] compared the microleakage of two types of bulk-fill composites (Filtek bulk-fill, 3M; SonicFill, Kerr) with the conventional Filtek Z250 in class II cavities. They found no significant differences between the three groups, and the gingival microleakage was greater than the occlusal microleakage in all groups. Although the dye was different (silver nitrate) and so was their scoring system, most of their findings came in accordance with the present study, except for the occlusal microleakage in group 3, which may be due to different cavity design and little depth of the occlusal section.

Higher gingival microleakage probably results from thinner enamel in gingival margins than occlusal. Gungor *et al.* [28] compared the microleakage of class II restorations in primary and permanent teeth using a conventional composite. Their results showed no significant difference in the occlusal microleakage, but the gingival microleakage was greater in the primary teeth, which may be due to the thinner enamel in primary teeth. Moreover, the primary enamel structure is less mineralized by calcium and phosphorus [29], and the primary dentine presents higher density of tubules and smaller intertubular dentine area [24]. All these factors may influence the composite microleakage in primary teeth.

Nevertheless, more clinical, and experimental studies are required to assess the outcomes of bulk filling technique in primary teeth, mainly with larger cavities than used in this study.

CONCLUSIONS

Within the limitations of this in vitro study, it can be concluded that the bulk-fill composite has a similar performance to the conventional composite in terms of gingival microleakage. The use of bulk filling technique by the conventional composite showed acceptable results in terms of microleakage in small class II cavities in primary teeth. The application of composite in several thin layers in low depth cavities may not be a preferable procedure. The use of bulk-fill composites may be preferred in restoring class II cavities in primary teeth in order to reduce working time, as the other properties are acceptable.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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