ORIGINAL PAPER

PRE-HEATING DECREASES MICRO-LEAKAGE OF BULK FILL COMPOSITE RESINS IN DENTIN MARGINS OF CLASS II CAVITIES: AN *IN-VITRO* STUDY

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ABSTRACT

Introduction: Low marginal adaptation and therefore micro-leakage, is one of the weaknesses of bulk fill resin composites. Pre-heating of composite resins reduces their viscosity, thus, increasing the marginal adaptation and decreasing their micro-leakage.

Objectives: The aim of this study was to examine the effect of pre-heating on micro-leakage of bulk fill composite resins in dentin margins of class II restorations.

Material and methods: This *in-vitro* study was conducted on 39 extracted human molars. Class II cavities were prepared on teeth's proximal surfaces. Teeth were divided randomly into three groups, which were restored using three different composites: Group 1 – X-tra fil composite; Group 2 – Opus Bulk Fill composite; and Group 3 – Gradia Posterior composite. Each group included 2 sub-groups: at room temperature and after one pre-heating cycle at 50°C. The teeth were placed in fuchsin solution for 24 hours and were examined for micro-leakage under a stereoscopic microscope. Mann-Whitney *U* and Kruskal-Wallis tests were applied with SPSS 16 software. *P*-value of less than 0.05 was considered significant.

Results: Pre-heating reduced micro-leakage significantly ($p < 0.001$). There was no significant difference in micro-leakage of different composites ($p < 0.05$).

Conclusions: Pre-heating to 50°C decreases micro-leakage in the dentin margin of class II restorations in bulk fill composites (X-tra fil and Opus Bulk Fill) and conventional composite (Gradia Posterior). Investigating the effect of various pre-heating procedures, such as different temperatures, duration, and repeated pre-heating on physical and mechanical features of bulk fill materials, is suggested for future studies.

Key words: composite resins, dental leakage, dentin, heating, X-tra fil composite resin.

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INTRODUCTION

Bulk fill composite resins are relatively new restorative concepts [1]. Bulk fill composite resins are used in up to 4 mm thickness layers without damaging the conversion degree or mechanical properties [2]. These composites have lower filler concentrations, which help in deeper light penetration [3]. Also, their photo-activation systems are more efficient [4], owing to their increased light transmittance [5]. Although these changes in structure result in greater polymerization at increasing depths, they might change the volumetric shrinkage and clinical

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performance of materials, such as marginal seal [6]. However, a systematic review has reported a lower polymerization stress for bulk fill restorations [7]. The important success factors of composite restorations are good adaptation of restorative materials to the teeth's surfaces and interfacial seal of the cavity walls [8]. Lack of proper adaptation and the resultant gap lead to micro-leakage of oral fluids and accumulation of bacteria, which result in sensitivity after restoration, marginal color change, and secondary caries [9]. Composite polymerization shrinkage is one of the reasons for the formation of gaps and micro-leakage [10]. There are several methods to resolve poor adaptation and micro-leakage, including using flowable composite liners with low viscosity before placing conventional composite, pre-heating of composites, and using soft start mode during curing [11]. Another technique to decrease adverse effects of polymerization shrinkage is the incremental placement of conventional composite resins. However, this method is time-consuming, and increases chances of void formation and cavity contamination [12].

Pre-heating of uncured resin composites is a method to enhance handling of the characteristics of composites during placement [13] that reduce their viscosity, leading to increased marginal adaptation and decreased micro-leakage [14]. Additionally, an increased temperature before polymerization causing a better conversion degree in resin composites [15], and an improved surface hardness and flexural and tensile strength have been reported [16]. A recent study using micro-CT analysis showed that pre-heated bulk fill composite resin can be effectively used at 68°C at both 2 mm and 4 mm thicknesses [17]. A study investigating the effect of pre-heating on bulk fill resin composites in class V cavities showed that the pre-heated composite had better marginal seal and less micro-leakage [18]. Another study showed that pre-heating significantly reduced shrinkage force in bulk fill resin composites, while not damaging the degree of monomer conversion [19].

OBJECTIVES

Since pre-heating has shown promising results in other types of resin composites, and the effect of pre-heating on the properties of bulk fill composites, including micro-leakage, has not yet been fully investigated, the objective of the current study was to assess the effect of pre-heating on micro-leakage of bulk fill composite resins in dentin margins of class II restorations.

MATERIAL AND METHODS

This *in-vitro* study was conducted on 39 sound human incisors without any caries, cracks, fractures, or anomalies, with mesiodistal dimensions of 8 to 12 mm and buccolingual dimensions of 8 to 12 mm. The Regional Ethics Committee has approved the study protocol (approval No.: IR.TBZMED.VCR.REC.1400.070).

SAMPLE SIZE

According to a study by Eman *et al.* [20], the mean and standard deviation of micro-leakage in two groups (i.e., Grandio Voco and Z250 3M ESPE) were equal to 1.1 ± 0.9 and 1.2 ± 1.9, respectively. Considering the first type error equal to 5% and power of the study of 80%, the number of 22 samples were obtained in each group. 20% was added to the sample size to increase validity of the study. Finally, 26 samples (cavities) in each composite group were considered. Since two cavities were prepared on each tooth, 13 teeth were used in each group.

SAMPLE PREPARATION

To disinfect the teeth, 0.1% thymol solution (Sigma-Aldrich, Ontario, Canada) was used for 48 hours [21]. The remains of tissues around the teeth and any calculus were removed with a standard curette, and kept in physiological serum for three months before the experiment. Using a turbine with air and water spray as a coolant and a 256-carbide bur, conventional class II cavities with a 2 mm pulpal depth, 3 mm wide, and 1.5 mm deep proximal box were prepared on both proximal surfaces of all teeth. The extension on occlusal surface was about 3 mm. Mesial and distal cavities were prepared, as the gingival floor of cavities was 1 mm beneath the cemento-enamel junction [21]. Then, the teeth were allocated randomly into three groups of 13 samples (26 cavities in each

TABLE 1. Description of composite resins used in the study

Composite resin	Type	Composition	Filler % volume
X-tra fil (VOCO, Cuxhaven, Germany)	Micro-hybrid	Matrix: Bis-GMA, UDMA, TEGDMA Filler: Barium-boron-alumino-silicate glass	70.0
Opus Bulk Fill (FGM, Joinville, Brazil)	Nano-hybrid	Matrix: UDMA filler: Silanized silicon dioxide (silica), barium glass aluminosilicate	58.4
Gradia Posterior (GC, Tokyo, Japan)	Micro-hybrid	Matrix: UDMA, dimethacrylate co-monomers Filler: Silica, pre-polymerized fillers, fluoro-alumino-silicate glass	65.0

Bis-GMA – bisphenol A-glycidyal dimethacrylate, UDMA – urethane dimethacrylate, TEGDMA – triethyleneglycol-dimethacrylate

group). Three composites were used to restore the teeth, two of which were bulk fill X-tra fil (VOCO, Cuxhaven, Germany) and Opus Bulk Fill (FGM, Joinville, Brazil), and one was a conventional composite Gradia Posterior (GC, Tokyo, Japan). Each group of composites was additionally divided into two sub-groups: at room temperature (24°C), i.e., non-preheated group, and pre-heated group, which received one pre-heating cycle up to 50°C. The composition of the resin-based composites used in the study are presented in Table 1. Based on the type of composite and pre-heating or not, 6 sub-groups were created. In sub-groups 1, 3, and 5, X-tra fil, Opus Bulk Fill, and Gradia Posterior composites, respectively, were cured at room temperature for 40 seconds with Demetron A2 LED Light Cure (Kerr, Scapatti, Italy) at a light intensity of 1,000 mW/cm^2. In sub-groups 2, 4, and 6, X-tra fil Opus Bulk Fill and Gradia Posterior composites, respectively, were heated for 15 minutes in a thermostatically-controlled hot water bath at a temperature of 50°C, and were applied to the cavities within 20 seconds. Syringes remained immersed in water for 15 minutes, so that the temperature of 50°C would be reached. A waterproof plastic bag protected the syringes during heating. There is an approximate 25°F decrease in temperature within 2 minutes after removing the composite resin from the heating unit. Therefore, it is important to place the composite as quickly as possible [22]. To ensure that the composite reached 50°C, the temperature of composite resins after pre-heating was checked once in each group. Then, the composites were cured for 40 seconds by a LED light cure device.

For restoration, matrix band was mounted around the teeth, and they were etched for 15 seconds with 35% N-Etch phosphoric acid gel (Ivoclar Vivadent, Schaan, Liechtenstein). The acid was rinsed off the surfaces for 15 seconds. After that, they were dried for about 3 seconds, and care was taken not to dry the teeth too much. Tetric N Bond (Ivoclar Vivadent, Schaan, Liechtenstein) bonding agent was applied on the dentine surfaces with a micro-brush according to the manufacturer's guidelines. The solvent slowly evaporated using air spray from a distance of 1 cm for 10 seconds. The surface of the bonded area became slightly shiny, and then cured for 10 seconds (all these procedures were done at room temperature). Bulk fill composites were placed in the cavities in a single layer, while the conventional composite was layered in 2 mm increments [17].

MICRO-LEAKAGE TESTING

After restoration, the teeth were incubated in distilled water at 37°C for 24 hours in the dark to ensure complete polymerization. Apexes of the teeth were filled with glass ionomer cement (Riva SDI, Sidney, Australia) to prevent secondary penetration of the material. Then, two layers of varnish were applied on the teeth at a distance of one mm from the cavity margin to prevent fuchsin penetration. The samples were placed in 0.5% fuchsin solution for twenty-four hours [23]. After immersing time, the samples were removed from the solution and washed under running water for 10 minutes to remove excess paint. Subsequently, the teeth were cut buccolingually with a diamond disc, and examined for micro-leakage by a stereoscopic microscope (SMZ 1,500; Nikon, Tokyo, Japan) with x40 magnification. The results were graded according to the following pattern: 0 – no micro-leakage; 1 – micro-leakage up to half of the gingival wall; 2 – micro-leakage of more than half the distance from the gingival wall to the axial wall; and 3 – micro-leakage up to the axial wall [11].

STATISTICAL ANALYSIS

Mann-Whitney *U* test was applied for comparison of micro-leakage in pre-heating and non-pre-heating groups for each composite. Kruskal-Wallis test was utilized for inter-group comparisons. Statistical analysis was performed with SPSS 16.0. *P*-value < 0.05 was considered significant.

RESULTS

The distribution of each micro-leakage score in the study groups is presented in Table 2. The mean micro-leakage score was significantly lower in pre-heating sub-groups than at room temperature sub-groups in all three composite resins ($p = 0.001$). Comparing the three types of composites without pre-heating indicated that there was no significant difference between micro-leakage scores ($p = 0.52$). Figure 1 shows micro-leakage of three composites at room temperature. In pre-heated composites, X-tra fill composite presented the lowest micro-leakage score, and there was not significant difference amongst three composites ($p = 0.41$). Figure 2 illustrates micro-leakage of the three pre-heated composites. Figure 3 shows a representative image of each score of micro-leakage in the study.

DISCUSSION

The aim of the present study was to investigate the effect of pre-heating on micro-leakage of bulk fill composite resins in the margins of class II restorations. Based on the results, the average amount of micro-leakage in pre-heated composites after heating to 50°C was significantly lower than at room temperature composites. There was no significant difference in micro-leakage scores between the three composite resins used at room temperature. In pre-heated composites, X-tra fill composite had the lowest micro-leakage score, but there was not significant difference among the three composites. Since

TABLE 2. Distribution of each micro-leakage score in the study groups

Composite resin	Sub-group	Micro-leakage score, *n* (%)			
		0	1	2	3
X-tra fil (VOCO, Cuxhaven, Germany)	Pre-heating	11 (42.4)	14 (53.8)	1 (3.8)	0 (0.0)
	Non-pre-heating	2 (7.7)	12 (46.2)	10 (38.4)	2 (7.7)
Opus Bulk Fill (FGM, Joinville, Brazil)	Pre-heating	8 (30.8)	16 (61.5)	2 (7.7)	0 (0.0)
	Non-pre-heating	2 (7.7)	8 (30.8)	12 (46.1)	4 (15.4)
Gradia Posterior (GC, Tokyo, Japan)	Pre-heating	10 (38.5)	14 (53.8)	2 (7.7)	0 (0.0)
	Non-pre-heating	1 (3.8)	7 (27.0)	17 (65.4)	1 (3.8)

0 – no micro-leakage, 1 – micro-leakage up to half of the gingival wall, 2 – micro-leakage of more than half the distance from the gingival wall to the axial wall, 3 – micro-leakage up to the axial wall

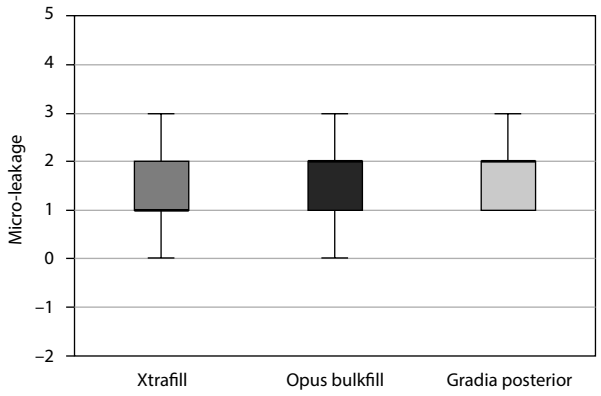

FIGURE 1. Box plot of mean micro-leakage score of three composites at room temperature

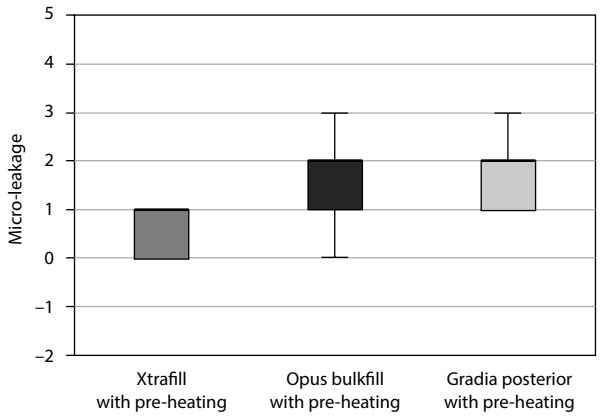

FIGURE 2. Box plot of mean micro-leakage score of three pre-heated composites

polymerization shrinkage is one of the leading causes of micro-leakage, many studies have concentrated on finding methods to decrease polymerization shrinkage in different types of composite resins. Tauböck *et al.* [19] indicated that pre-heating of bulk fill and conventional resin composites decreased the polymerization shrinkage, but the degree of conversion was unaffected. Similarly, Darabi *et al.* [24] reported that marginal gaps on dentin walls were significantly lower in both bulk fill and conventional composites after pre-heating up to 68°C compared with room temperature.

In the present study, the average amount of micro-leakage in pre-heated composites was significantly lower than that at room temperature composites. Similarly, a study by Dilian and Kadhim [21] showed that the pre-heated bulk fill restoration showed lower micro-leakage compared with unheated bulk fill composites. This might be explained that raising the composite temperature reduces material viscosity and increases molecular mobility due to the increased thermal energy, resulting in more polymerization. However, a study by Elbahrawy and Attia [25] showed that pre-heating of bulk fill composites has no effect on micro-leakage. This discrepancy could be caused by different brands of materials used. In Elbahrawy and Attia's study, Tetric Evoceram bulk fill and Tetric Evoceram (Ivoclar Vivadent) composite resins were utilized.

In the current study, no difference was observed in micro-leakage of bulk fill composites compared with conventional ones. In contrast, a study by Arora *et al.* [26] showed that the pre-heated bulk fill composites had lower micro-leakage compared with nano-hybrid composites. It should be mentioned that restorations in Arora *et al.* [26] study were done on endodontically-treated teeth, and the present study used class II cavities. The volume of the composites used in these two studies might be the reason for this difference.

In the current study, no significant difference was observed in micro-leakage scores between different brands of composites. Although, Kincses *et al.* [27] concluded that the effect of pre-heating on characteristics of composites depends on the brand and composition of resin-based composites.

Due to different thermal expansion coefficients between enamel, dentin, and composite resins, thermocycling might have affected the scores of micro-leakage; therefore, the main limitation of this study is not using thermo-cycling. Another limitation of this study is that it did not investigate the long-term effects of pre-heating on micro-leakage of the bulk fill composites used. Also, limited number of the investigated bulk fill composites

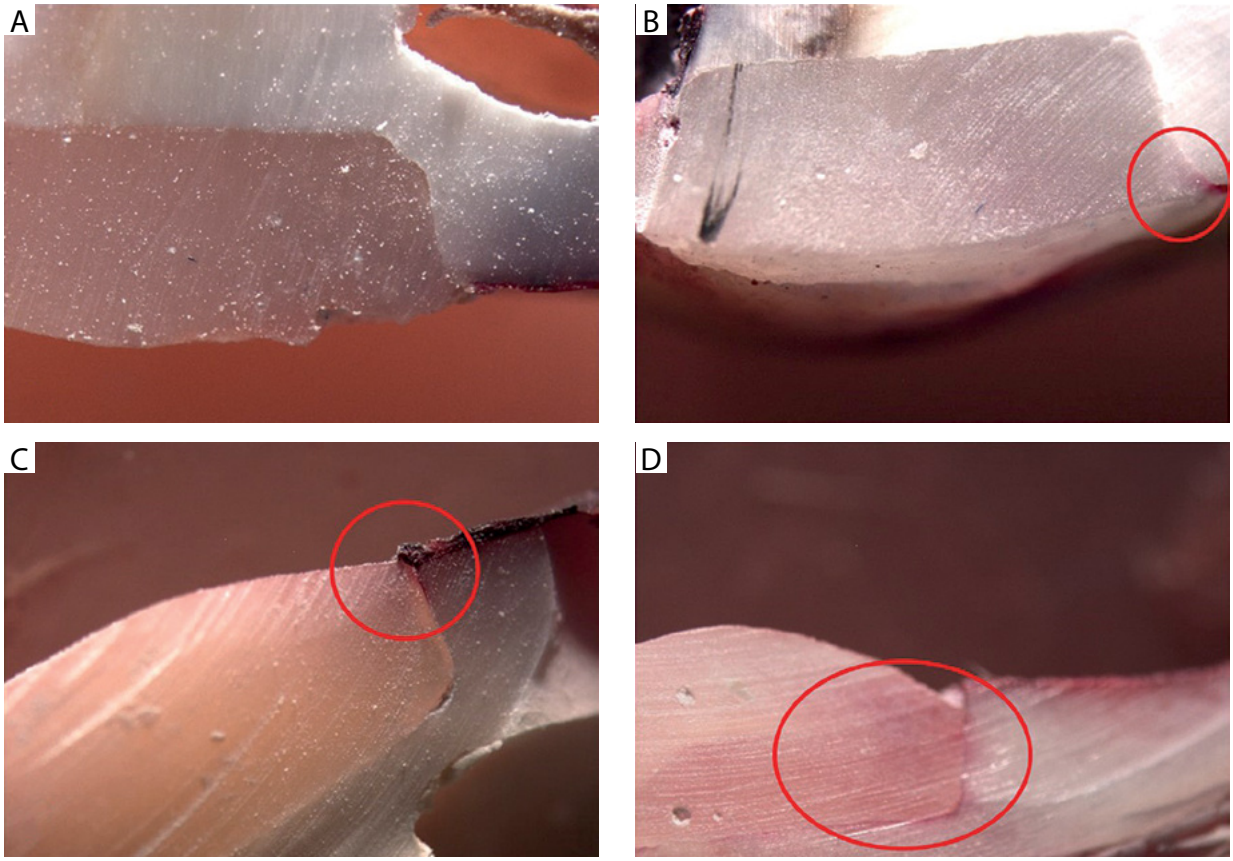

FIGURE 3. Different micro-leakage scores. **A**) Score 0, **B**) score 1, **C**) score 2, **D**) score 3

is a drawback, because the results are highly material-dependent. Long-term clinical studies are recommended to evaluate the clinical performance of pre-heated bulk fill resin composites.

CONCLUSIONS

Based on the results, the pre-heating of the bulk fill composites (X-tra fil and Opus Bulk Fill) and conventional composite (Gradia Posterior) up to 50°C decreases the micro-leakage of the dentine margin in class II cavities. Furthermore, there is no difference in the micro-leakage of bulk fill composites and Gradia Posterior composite both at room temperature and after pre-heating. Future studies evaluating the effect of various pre-heating procedures, including different temperatures and pre-heating times, and repeated pre-heating on physical and mechanical features of bulk fill materials, are suggested. Furthermore, long-term research with thermo-cycling is recommended to evaluate the micro-leakage of pre-heated bulk fill restorative materials.

DISCLOSURES

1. Institutional review board statement: The study was approved by the Regional Ethics Committee of the Tabriz University of Medical Sciences, with approval number: IR.TBZMED.VCR.REC.1400.070.
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