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Marginal Sealing of Bulk Fill versus Conventional Composites in Class II Composite Restorations: An In Vitro Study

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A B S T R A C T

Objectives: Bulk fill composites are preferred to conventional composites with time-consuming incremental application technique, given that they have good mechanical properties and low microleakage. The aim of this study was to evaluate and compare the dentinal marginal microleakage of bulk fill (in two viscosities) and conventional composites in class II cavities in maxillary premolars.

Materials and Methods: In this in vitro study، 42 class II cavities were prepared in the mesial and distal surfaces of 21 maxillary premolars extending 1 mm below the cementoenamel junction, and restored with Grandio composite with 2-mm increments, and X-tra fil and X-tra base with 4-mm increments. After 24 h of storage at 37°C and 100% humidity, they were thermocycled (500 cycles، 5-55°C), stored in basic fuchsine, sectioned, and evaluated under a stereomicroscope (×40). The microleakage scores of the gingival margin were recorded. Statistical analysis was done by SPSS 21 via the Kruskal-Wallis and Mann-Whitney U tests at P≤0.05 level of significance.

Results: No statistically significant differences were noted among the groups in marginal microleakage (P=0.47). No statistically significant difference was noted between bulk and incremental application techniques in this respect either (P=0.23).

Conclusion: There was no difference in marginal microleakage between the bulk fill and conventional composites.

Keywords: Composite Resins; Dental Leakage; Dental Restoration, Permanent

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INTRODUCTION

Composite resin restorations have recently attracted further attention and are used in abundance [1]. Adequate polymerization of conventional composites does not occur at depths greater than 2 mm, and using the incremental technique to overcome this shortcoming is time consuming in extensive restorations. Also, the possibility of void formation between the increments is another major disadvantage of the incremental technique [2]. Polymerization shrinkage is an undesirable characteristic of composite resins [3]. If polymerization shrinkage exceeds the bond strength at the interface, a marginal gap is formed to release the stress. The gap size increases under occlusal forces, leading to fluid accumulation and subsequent microleakage, marginal staining, post-operative sensitivity, enamel microcracks, cuspal fracture, passage of bacteria and their products, marginal demineralization, and recurrent caries [4-6]. These conditions are exacerbated when the gap forms at the dentinal margin; thus, achieving a tight marginal seal is fundamental for clinicians [1,7]. The recent introduction of bulk fill composites allowed the application of composite as bulk, which has created some concerns with regard to polymerization and the possibility of leakage [4]. The shrinkage stress has decreased in bulk fill composites (2-3%) due to changes in the methacrylate monomers and also the reduction in the amount of TEGDMA (compared with the original Bowen formulation) [8]; while, their strength and elastic modulus are favorable because of high filler content. The rate of polymerization is slower in bulk fill composites [9], and the shrinkage stress is reportedly between 1.7-2.4 MPa [8]. Moreover, their greater translucency allows proper penetration of light, which results in a degree of polymerization comparable to that of conventional composites [10,11]. Lower elastic modulus and shrinkage stress can reduce microleakage, postoperative sensitivity and secondary caries [8]. Additionally, there is no need to use a specific adhesive system for the bulk fill composites. By developing bulk fill resins, the manufacturers recommend to increase the thickness of each composite layer to 4-6 mm [4]. Behery et al. [12] claimed that the gingival microleakage of bulk-fill composites in class II cavities was not significantly different from that of incrementally restored cavities with a conventional composite, although the risk of formation of internal marginal gap by applying a large volume of composite needs to be investigated [4].

In absence of clinical information, in vitro studies regarding microleakage are an acceptable method to assess the marginal adaptation of adhesive restorations [13]. The quality of marginal seal and the clinical success of restorations depend on a number of factors such as the adhesive system used, the amount of shrinkage stress, and the degree of conversion of composite [10]. In the clinical setting, these stresses can be transferred to the restoration margins and affect the quality of marginal seal. The polymerization shrinkage stress also depends on other factors such as the material volume, the elastic modulus, and the curing technique [10]. In an in vitro study by Scotti et al, [1] the marginal sealability of a bulk fill flowable composite resin was evaluated in enamel and dentin. They found that the bulk fill composite provided a better marginal seal in the dentin. Furness et al. [4] evaluated the effect of composite type (bulk fill/conventional) on the internal marginal adaptation. They concluded that there was no significant difference in marginal gap between different composite types. A systematic review and meta-analysis reported that the failure rate was not significantly different between the conventional and flowable bulk fill composites [14]. Considering the limited number of studies comparing the marginal seal of bulk fill (X-tra fil and X-tra base) and conventional composite resins, this study aimed to assess the amount of microleakage in class II composite restorations of human premolars with gingival dentin margins. Composites in two viscosities (paste and flowable) and two application techniques (incremental and bulk filling) were compared. The null hypothesis was that the microleakage would not be different at the gingival margin of the cavities in bulk filling and incremental application techniques.

MATERIALS AND METHODS

This in vitro experimental study was performed on 21 human sound maxillary premolars extracted due to orthodontic treatment (42 samples). The study was approved by the ethics committee of Kerman University of Medical Sciences (IR.KMU.REC.1395.769). The teeth were free from caries, cracks, and hypoplastic defects in the proximal region, and after removal of soft tissue, they were stored in distilled water. It should be noted that the dimensions of the teeth were measured using a caliper. Two mesio-occlusal (MO) and disto-occlusal (DO) boxes were prepared with 01 cylindrical diamond bur (Teezkavan, Tehran, Iran) and high speed handpiece under air and water coolant. The occlusal width was ½ of the buccopalatal width, the box width was ½ of the buccopalatal width, and the depth of the cavity was 2 mm in the occlusal and 1.5 mm in the proximal surfaces [15]. The cavosurface angles were prepared at 90° and all line-angles were rounded. The gingival margins were also prepared in dentin below the cementoenamel junction. A new bur was used for every five preparations. Next, the teeth were mounted up to 3 mm below their cementoenamel junction in transparent acrylic resin (Acropars, Tehran, Iran). The teeth were then randomized into three groups (each group contained 7 teeth, each with two class II boxes). Restorations were performed after fixing the metal matrix band using a Tofflemire matrix holder. The matrix band was held in place using a lockable forceps in the gingival area during restoration to prevent overfilling of the cavity in the gingival region. The specifications of the materials used in this study are presented in Table 1. In all groups, dentin and enamel conditioning and bonding were performed by the two-step etch-and-rinse method using 35% phosphoric acid for 20 s for the enamel and 15 s for the dentin areas according to the manufacturer's instructions. After washing for 20 s and blot drying, one coat of Solobond M was applied on all etched surfaces for 30 s using a microbrush. After air drying, curing was performed using a LED curing unit (LITEX 686; Dentamerica, Taiwan) with 700-800 mW/cm^2 intensity for 20 s. Composite was then applied.

- **X-tra fil** composite group: Composite was applied with 4 mm thickness in the proximal boxes and then curing was performed for 40 s. The next increment was applied to form the tooth anatomy.
- **X-tra base +** Grandio composite group: X-tra base composite with 4 mm thickness was injected into the boxes. Curing was performed Similar to the previous group. Next, 2-mm increments of Grandio composite were applied to form the tooth anatomy, followed by curing.
- **Grandio** composite group: The cavity was filled incrementally (wedge-shaped increments with a maximum of 2 mm thickness).

Finishing was performed after opening the matrix band using diamond finishing discs (Sof-Lex; 3M ESPE, St. Paul, USA) and low-speed headpiece under air-water coolant.

The samples underwent 500 thermal cycles between 5°-55°C with a dwell time of 60 s and a transfer time of 30 s (Baradaran Pouya, Tehran, Iran). In the next step, all tooth surfaces except for 1 mm band around the restoration margins were covered with two layers of nail varnish. After drying of the nail varnish, they were immersed in 0.5% basic fuchsine solution for 24 h and were then washed under running water. After mounting of the specimens in transparent acrylic resin, each restoration was split in half in mesiodistal direction using a handpiece (Marathon-N1, South Korea) and a diamond disc (D & Z, Germany) under water irrigation such that the cut passed through the center of each restoration. The sections were observed under a stereomicroscope (Carl Zeiss, Oberkochen, Germany) at x40 magnification by two calibrated observers, and the degree of dye penetration at the gingival margin was determined and scored as follows:

0- No dye penetration in the gingival margin

1- Partial dye penetration (less than half of the cavity depth at the gingival margin)

2- Dye penetration by more than half of the cavity depth at the gingival margin and no involvement of the axial wall.

3- Dye penetration extending to the axial wall and more. Data were analyzed by SPSS version 21. Since the microleakage level was scored from 0 to 3, the non-parametric Kruskal-Wallis test was used to compare the composites and the Mann-Whitney U test was used to compare the application methods (incremental and bulk filling). $P \leq 0.05$ was considered statistically significant.

RESULTS

Table 2 shows the amount of microleakage at the dentin margin. Table 3 demonstrates the comparison of the composites in terms of microleakage. Kruskal-Wallis test showed no significant difference between the three composites in terms of microleakage (P=0.47).

Table 1. Materials used in this study, all obtained from Voco, Germany

Materials	Type	Composition
Solobond M	Etch-and-Rinse adhesive	Bis-GMA, HEMA, BHT, acetone, organic acids
Grandio	Conventional Composite	Bis-GMA, TEGDMA, Fillers: 87wt%, 71.4vol%
X-tra fil	Bulk Fill Composite	Bis-GMA, UDMA, TEGDMA, Fillers: 86wt%, 70vol%, Ba-B-Al-Si glass
X-tra base	Bulk Fill Flowable Composite	Bis-EMA, MMA, Fillers: 75wt%, 58vol%, Si glass
Vococid	Etchant	35% phosphoric acid

Table 2. Microleakage scores at the dentin margin in the three groups

Groups	Microleakage scores			
	0	1	2	3
Grandio	2	8	3	1
X-tra fil	2	5	5	2
X-tra base	2	4	6	2

Table 3. Comparison of mean microleakage (± standard deviation, SD) among the three composites

Groups	Mean ±SD	Mean Rank	X^2	df	P
Grandio	1.21±0.8	18.46			
X-tra fil	1.5±0.94	22.46	1.5	2	0.47
Xtra base	1.57±0.93	23.57			

Table 4. Comparison of mean microleakage scores (±standard deviation, SD) based on the restoration technique

Groups	Mean±SD	Mean Rank	MW-U test	P
Bulk filling	1.53 ±0.92	23.02	153.5	0.23
Incremental	1.21±0.8	18.46		

MW-U test: Mann Whitney-U test

The Mann-Whitney U test was used to compare the application methods, and revealed no significant difference in the microleakage scores between the bulk filling and incremental application techniques (P=0.23, Table 4).

DISCUSSION

During the early 2000s, the idea of producing a composite resin suitable for thicknesses greater than 2 mm with a higher translucency than previous composites was presented. By changing the formulation of monomers, it is possible to decrease the shrinkage stress during polymerization, cusp flexure, and gap formation without reducing the degree of conversion [16]. One of the most important goals in restoration of cavities is to obtain a reliable marginal seal to prevent microleakage and its clinical consequences.

The main advantage of bulk fill composites is to increase the curing depth due to higher translucency and more efficient initiator systems, and lower polymerization shrinkage due to changes in the filler content or the organic matrix [17]. It is claimed that slower polymerization in some bulk fill composites during curing causes a gradual increase in the elastic modulus, which makes it possible to reduce stress without decreasing the degree of conversion of composites [18].

According to the results of this study, the null hypothesis was confirmed since there was no significant difference in microleakage at the dentinal margin between the conventional and bulk fill composites (P=0.47). There was no significant difference between the two viscosities of bulk fill composites either. In the context of comparing the marginal adaptation of bulk filling and incremental conventional filling techniques, many authors have reported relatively similar results and found no difference between them [18]. In a study by Benetti et al, [19] the gap formation in flowable bulk fill composite was higher than that in the conventional and non-flowable bulk fill composite. In a study by Al-Harbi et al, [20] the quality of cervical margin in bulk fill composites was better than that in the conventional composites with incremental application technique. The lower polymerization stress in flowable bulk fill composites is related to their flowability before reaching the gel point [17], which is in agreement with our results. X-tra base has a low shrinkage value (2.7%) within the acceptable range [19]. Kim et al. [18] concluded that bulk fill composites with high consistency were similar to conventional incremental composites in terms of tooth-restoration interfacial debonding. Van Ende et al. [21] revealed no difference in gap size between bulk filling (of bulk fill composites) and incremental application (of conventional composites) in class II composite restorations, which is similar to our study result.

According to the results of our study, there was no significant difference in the dentin margin microleakage between the two types of bulk fill composites with paste and flowable consistencies. The lining materials such as flowable composites can help in better distribution of stress at the adhesive-tooth interface, by acting as a stress breaker [13]. One of the advantages of the bulk fill flowable composites can be the possibility of better adaptation at the margins as well as lower elastic modulus resulting in lower risk of microleakage [15]. Agarwal et al. [22] compared the marginal adaptation of several bulk fill composites with paste and flowable consistencies using a scanning electron microscope. They found that the adaptation was lower in the dentinal margin in use of bulk fill composite with paste-like consistency. Although the use of composite with higher consistency is more desirable in order to obtain proper proximal contact, they might have poor adaptation to the cavity walls [22]. Among all the factors contributing to gap formation, the adhesive bond quality and efficacy also play important roles in maintaining a proper contact between the composite and the cavity walls, and this is more important at the enamel margins. As a result, identifying an adhesive system with good adhesion quality can reduce the possibility and extent of gap formation and can decrease the role of restorative material in this respect [19]. In other words, the marginal sealability of a material depends on the simultaneous effect of the adhesive system and the type of restorative material. An important parameter about adhesives is their water sorption and hygroscopic expansion, which can cause swelling of the adhesive layer by the same degree in different types of adhesive materials. For example, this value is 0.9% for the Solobond M. This can affect the interfacial morphology and cover the irregularities at the interface and small gaps that are not even visible under a scanning electron microscope [23]. Limited information is available regarding the long-term stability and blocking of margins by swollen adhesives. Debonding of these areas as the result of application of mechanical forces is highly probable, causing an increase in the amount of gap, and compromising the marginal integrity of restorations [23].

In the present study, the samples were subjected to thermocycling. Generally, restorations are exposed to many alterations in the oral environment, including high thermal alterations and pH changes. Thermal changes occur frequently during eating and drinking. Therefore, thermocycling is considered as an important process in assessment of the sealing ability of restorative materials [24], and can affect the results.

CONCLUSION

The amount of microleakage at the dentin margin of class II restorations was similar in use of the conventional incrementally applied composite (Grandio) and bulk fill (X-tra fil) and flowable bulk fill (X-tra base) composites. There was no difference in the amount of microleakage between the two bulk fill composite consistencies either.

CONFLICT OF INTEREST STATEMENT

None declared.

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