Volume 2022, 8 pages
Article ID : EML-2211062112822

Journal of Express Medical Letters

http://www.htpub.org/Express-Medical-Letters/

ISSN: 2783-4123

Comparison of Marginal Adaptation of Flowable Bulk Fill Composites and Conventional Composites in Class V Cavities

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Article

Received: 03th August 2022
Received in revised form: 04th November 2022
Accepted: 11th November 2022

Keywords:
Flowable Bulk Fill Composites,
Class V Cavities,
Marginal Adaptation,
Microleakage

Abstract

Background and Objectives: Today, to improve the compatibility and performance of restorative materials, new types of composites have been developed which are different from traditional composites, such as Flowable, Bulkfill and Nanofill composites. This study aimed to compare the marginal adaptation of Flowable Bulkfill composites and conventional composites in Class V cavities.

Materials and Methods:30 human molar teeth in 3 groups of Flowable Bulkfill composites from two companies of 3M and Tokuyama and Conventional composite from 3M, were prepared in standard class V cavities (dimensions 4 * 2 * 1.5 mm) in buccal surface of teeth with a gingival margin of 0.5mm lower than CEJ.

Results: The results showed that there were statistically significant differences in the use of all three composites in the two types of enamel and dentin margins ($p < 0.05$). In all three types of composites dye penetration was the most frequent. Considering the degree of marginal adaptation, there was little difference between the amount of marginal adaptation by all the three types of composites ($p > 0.05$).

Conclusion: The results of the present study showed that the distribution of marginal adaptation in two types of Tokuyama Flow and 3M Conventional Z250 composites had similar conditions, while the 3M Flowable Bulkfill composite acted a little better than other two composites, but the difference was not statistically significant.

Introduction

Today, in order to enhance the matching and performance of cosmetic restorative material, different new types of composites have been manufactured. Flowable Composites were introduced in the mid-1990s. Due to their filler contents, these composites are more flowable. Their lower elasticity coefficient absorbs tensions during the polymerization process [1]. This characteristic of flowable composites has persuaded a group of researchers to announce it suitable for restoring Class V cavities, which are usually subject to tensile force. The lower viscosity of these types of composites gives them easy handling attributes while using in syringe. Despite having the advantages mentioned above, the low filler content of these composites causes more contraction compared to conventional composites. The contraction in flowable composites

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may lead to microleakage. The negative clinical outcomes of microleakage can be categorized as secondary decay, pulp inflammation, marginal color change, sensitivity, and shorter restorative durability [2].

Efforts to minimize the contraction in the polymerization process and microleakage, together with shorter required working time alongside other advantages of flowable composites, resulted in the introduction of flowable bulkfill composites. According to their manufacturers claim, the flowable bulkfill composites allow satisfactory light penetration up to 4 mm, have a high volume of fillers (more than 50% volume) similar to conventional composites and a low contraction and, perfect handling. Flowable bulkfill composites are compatible with cavity walls and, their application can lower the marginal defects in restoration. These composites project a better function in Class V cavities due to the cuspal deflection and tensile tensions affecting the cavities ([3, 4, 5, and 6]. Also, due to their ease of use, they have a faster and satisfactory function with less collaborative patients [7].

In regards of the importance of selecting the material in class V restorations and its technical sensitivity caused by different factors such as isolation and humidity control also, the importance of microleakage and its effects on the success rate of restorative treatments, in this study we have focused on marginal adaptation of flowable bulkfill composites and conventional composites in class V cavities. Our first null hypothesis is based on the better functionality of flowable bulkfill composites in comparison with the conventional composites in class V cavities. The second assumption suggests a better function in enamel bond compared to dentin bond.

Materials and Methods

This study was carried out on 30 samples of the third molar teeth of the upper and lower of human jaw. In case of any decay, crack and/or fracture and other dental defects such as fluorosis and enamel hypoplasia, the samples were eliminated from the study. Blood and periodontium were removed and the samples were cleaned using pumice and brush and were kept in chloramine solution (2%) at room temperature until the commencement of the study. Standard class V cavities at 4mm (mesio-distal), and 2mm (occluso-gingival), and 1.5mm (axial depth) were made using 245 fissure diamond burs (D&Z, Frankfurt, Germany) with high speed handpiece and water spray at the buccal surface of all the samples with a gingival edge at 0.5 mm lower than CEJ.The burs were changed after completing each five cavity preparation. All cavities were prepared by one member from the study team. Then, the teeth were divided into three random groups. The cavities were etched by phosphoric acid 37% (3M, ESPE, USA) for 15 seconds and were washed for 10 seconds. Teeth surface was air-dried. Then two layers of Adper Single Bond (3M, ESPE, USA), were applied in the cavity by micro brush as per the manufacturer's instructions. 5 seconds of mild air followed by light cure for 20seconds at the rate of 1500mv/cm2 and wavelength of 480nm (Dent America, Taiwan). Cavities of 10 tooth samples were filled in layers with conventional composite (3M, ESPE, USA). A2 shade was selected. 1/3 occlusal, 1/3 middle, and then 1/3 gingival was restored, then each layer was cured for a duration of 20 seconds.In the 2nd and 3rd groups, restorations were done by Filtek Bulkfill Flowable Restorative (3M, ESPE, USA) and Palifique Bulk Flow (Tokuyama, Japan) accordingly by selecting A2 shade and bulk filling in a single round. The fillings were light-cured for 40 seconds. The power of the light cure device was measured by radiometer (Radiometer Medical Aps, Denmark). The materials chemical composition are shown in table 1.

Table 1 The materials chemical composition

Manufacturer	Components	Materials
3M , USA	%32-%34 Phosphoric acid	Scotchbond Universal Etchant
3M , St.Paul , Minnesota , USA	Bis-GMA , HEMA , Dimethacrylate , Ethanol , Water , Photoinhibitor system , Methacrylate of polyacrilic and polyiatronic acids	Adper Single Bond 2 Adhesive
Tokuyama Dental , Osaka , Japan	Bis-GMA , Bis-MPEPP , TEGDMA , Supranano filler (Silica/Zirconia)	Tokuyama Flow
3M , St.Paul , Minnesota , USA	Bis-GMA, UDMA , TEGDMA , Bis-EMA resins , non agglomerated Silica filler , non agglomerated Zirconia filler , non aggregated Zirconia/Silica cluster filler	Filtek Z250 Universal Restorative
3M , St.Paul , Minnesota , USA	Bis-GMA , UDMA , Bis-EMA , Procrylat resin , Filler Zirconia/Silica	Filtek Bulkfill Flowable Restorative

The samples were polished using aluminum oxide discs (EVE, Germany), and post-cured for 20 seconds. Then the teeth were put in distilled water with a temperature of 37 degrees celsius for 24 hours. Samples were thermo-cycled for 1000 cycles between 5-55 degrees celsius (±2 degrees celsius) with a dwell time of 30 seconds and a transfer time of 10 seconds [8]. The samples were stored at a temperature of 37 degrees celsius for 24 hours. [6 7] Then the end tip of each tooth root was sealed with wax. All the tooth area except one millimeter next to the fillings was covered by nail polish. To determine if the upper layer of nail polish has completely coated the lower layer, two different colors of nail polish were selected to ensure the penetration from cavity walls. Samples were then dipped in fuchsin solution (0.5%) at a temperature of 37 degrees celsius for 24 hours. Samples were washed in running water and dried after.

The teeth were mounted in special molds with self-curing acryl (Acropars, Marlic, Tehran) and were cuted facio-lingually in the middle by a diamond disc (Nemov, Mashhad, Iran) at a low speed while being water sprayed.

Each restoration was observed by a binocular stereomicroscope (Dewinter, India) with Diopter x12 in occlusal and gingival margins. Images were photographed and microleakage were analyzed.

The microleakage degrees were as follows:

0 = no dye penetration

1 = dye penetration up to ½ of occlusal and gingival walls

2 = dye penetration more than ½ of occlusal and gingival walls

3 = dye penetration to axial wall(8)

To analyze the data, first, a descriptive statistics approach was adopted, including an average ± of diversion in microleakage value. The outcome was summarized based on Kolmogorov Smirnov Test to compare the normality. If normal, Two Parametric T-Test was utilized. If not, the Non-Parametric Mann Whitney Test was applied. In case of any interventional effect, Linear Regression with the significance level of 0.05 was used. SPSS-24 software was put into work for data analysis.

Results

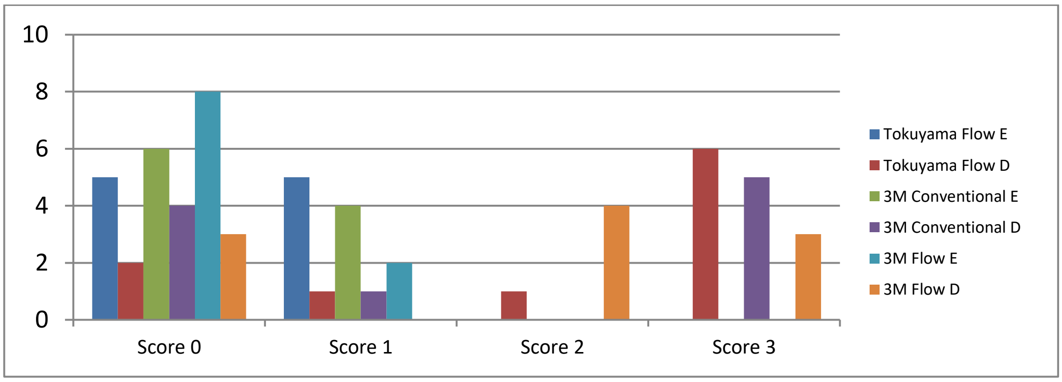
To determine the distribution of marginal adaptation in the two types of enamel and dentin edges while using three types of composites in class V cavities Pearson's chi-squared test was applied. Based on the extracted results, the marginal adaptation in two types of enamel and dentin edge showed a significant statistical difference and the distribution of marginal adaptation was not homogenous ($p < 0.05$). According to acquired data from the test (Table 2), it can be stated that in Tokuyama Flow composite in enamel edge no dye penetration and dye penetration up to ½ of gingival and occlusal walls was equivalent to half of the total frequency in Enamel Edge. Whereas in Dentin edge the maximum frequency was related to dye penetration microleakage at axial walls (60%). The test in determining the distribution of marginal adaptation in the two types of enamel and dentin edge for 3M Conventional Z250 in class V cavities showed in enamel edge no dye penetration, and dye penetration up to ½ of gingival and occlusal walls were 60% and 40% accordingly. While in dentin edge, the maximum frequency for marginal adaptation was related to the axial wall with 50%.

Microleakage	**Margin**	**Score 0**		**Score 1**		**Score 2**		**Score 3**		**P-value**
Composite		n	%	n	%	n	%	n	%	
Tokoyama Flow	Enamel	5	50	5	50	0	0	0	0	0.012
	Dentin	2	20	1	10	1	10	6	60	
Conventional Z250	Enamel	6	60	4	40	0	0	0	0	0.027
	Dentin	4	40	1	10	0	0	5	50	
3M Flow Bulk Fill	Enamel	8	80	2	20	0	0	0	0	0.01
	Dentin	3	30	0	0	4	40	3	30	

The chi-squared test results to determine the homogeneity of marginal adaptation in enamel and dentin in 3M Flowable Bulkfill Composite for class V cavities showed the microleakage in enamel edge only in case of no dye penetration (80%) and dye penetration up to ½ of gingival and occlusal walls (20%). No penetration at the Axial wall was recorded. However, the maximum microleakage in dentin edge for dye penetration was in more than ½ of gingival and occlusal walls (40%). Dye penetration at the axial wall of the cavity was 30%.

By comparing the marginal adaptation values in the three different types of composites, it can be concluded that no significant statistical difference was visible among the abovementioned groups. However, 3M Flowable Bulkfill composite demonstrated better function compared to the other two types.

The comparative results for composites' functionality on enamel and dentine edges are summarized in column 1.



Discussion

Due to decay, aesthetic, or sensitivity, the class V defects may require restorative treatment. The restorative material used in such treatments is mostly chosen from isochromatic types such as composite resins, glass ionomer, or compomer fillings [9, 10, 11, and 12]. Resin composites due to their advantages, including dental color match, Mercury-free, no heat convection, bio-friendly, dental structure bonding, better preservation of dental tissue compared to indirect treatments, also price competency and their physicomechanical characteristics, are the choice in the treatment of anterior and posterior teeth. The one of generation of composite resins (flowable composites) that are available in the market, have less filler content. Studies have shown that they have three times less elasticity index compared to regular hybrid composites [13]. The stress distribution is determined by contraction and elastic module of materials. The contraction in the polymerization can cause increased stress at the surface of the adhesive. However, the lower elastic module in flowable composites enables them to flow during the polymerization process and resist the relevant stress, resulting in better sealing [14 and 15]. Based on the above mentioned characteristics of flowable composites, a group of researchers has recommended them for Class V cavity restorations.

In the current study, we focused on the marginal adaptation of flowable bulkfill and conventional composites in class V cavities. To match the oral environment, the samples were thermocycled.

The obtained results showed that there was a significant difference in marginal adaptation at enamel and dentin edges between the tested composites. The edge distribution was not similar in the enamel and dentin margins. The color penetration to axial wall at the dentin section restored by Tokuyama Flow was 60%, by 3M Conventional Z250 was 50%, and for 3M Flowable Bulkfill composite was recorded at 30%.The above results suggest the strongest performance by 3M Flowable Bulkfill Composite, where Tokuyama Flow recorded the weakest performance. Similar results were obtained while testing on the enamel. However, there was no significant statistical difference between the samples while testing on the enamel and dentin. This different performance and microleakage difference by Tokuyama Composite can be due to different chemical ingredients, different formulas, and treatment approaches considered by its manufacturers [16].

The structural difference of their tissue can justify the difference in miroleakage between enamel and dentin edges. The stronger bond between composite and enamel is due to this difference. Enamel has more mineral texture (90% by volume) where dentin consists of more water and organic material, which gives it more humid surface and lower surface energy. A higher level of microleakage is to be expected in dentin edge. In the meantime, dentin tubules and tubular fluid cause weaker bonding in dentin compared to enamel. However, on the sidelines of enamel, microleakage causes a percentage of penetration, which confirms that the adhesive quality of the enamel is unable to overcome the volume contraction of applied material [17, 18, and 19]. In a study conducted by Sooraparaju et al. similar results were obtained in composites applied on enamel and dentin edges. According to their study, there was a significant difference between restored cavities by bulkfill and flowable composites and more microleakage was recorded at the dentin edge [19]. Zhu et al. analyzed three types of conventional nano-hybrid, Flowable, and Bulkfill Composites in a study in 2017. Their study showed a significant lower level of micoleakage while applying Tetric Bulkfill in gingival edge compared to the other two types. In the meantime, the projected statistical difference in micoroleakage between enamel and dentin edges was significant [20]. The results extracted from their study were similar to the results of the current study in terms of the differences between the two edges of restoration. Their study also suggested better performance of bulkfill composite for class V cavities in comparison with conventional composites.

Lokhande et al. had contrary findings. They did not testify any significant difference in microleakage levels between different types of bulkfill composites while conducting their tests on enamel and dentin surface. They also confirmed none of the composites used, projected no color penetration [8]. The latter was similar to the obtained results in the current study. Lower micoleakage level and better sealing in the sidelines of enamel is related to a lower level of organic ingredient in enamel compared to dentin. However, in the margin of enamel, microleakage causes a level of penetration, which confirms that the adhesive quality of the enamel is unable to resist volume contraction of applied material.

The results of the current study showed that considering the marginal adaptation quantity, there is no difference between the composites in terms of marginal adaptation. This study also suggested that 3M Flowable Bulkfill composite had 80% of no dye penetration at the enamel. However, Tokuyama Flow and 3M Conventional Z250 composites had 50% and 60% of no dye penetration relatively. Based on the above results, it can be stated that Tokuyama Flow and 3M Conventional Z250 composites have a similar condition in regards to marginal adaptation where 3M Flowable Bulkfill is slightly different.

We assume that composite material filled by bulkfill material tested in the current study have more satisfying results in terms of marginal adaptation. Bulkfill composites are more transparent than other restorative materials. This attribute lets the light reach deep layers. Bulkfill technique makes restorative treatment easier undoubtedly, and in the case of intense and expanded cavities, it reduces clinical work time [4 and 5]. However, there is limited data in our current achievement.

Moreover, flowable composites can be applied to tiny cavities. This attribute promises better compatibility and bonding with inner walls of cavities compared to other types of restorative composites with stickier characteristics [21]. These findings in flowable composites' properties affirm their suitable behavior. Gupta et al. studied the capability of marginal seal in bulkfill composite resins in 2017. According to their finding, there was no significant statistical relationship in the capability of marginal seal in bulkfill composite resins at enamel and dentin. They concluded that the capability of the marginal seal in bulkfill composite resins is not subject to the flow ability of the material [22]. In another study by Caixeta et al., three groups of conventional, flowable, and bulkfill composites were put into a test for their bonding strength. The results were similar to our study. The Filtek Z350 XT, and Filtek Z350 XT Flow composites portrayed better performance compared to Bulkfill X-trafil (Voco). Bonding strength of Bulkfill X-trafil (Voco) was significantly lower than the other two tested samples. Caixeta noted that the difference between the three composites could be due to differences in composites' mixture and nature of the material. They concluded that X-trafil composite has a bigger tensile coefficient compared to the other two samples due to its non-organic ingredients (63.3% of volume), which reduces the resistance against contraction stresses [23]. Based on the above, it seems that each product shows better compatibility with bonding material from the same brand. It is advisable to use the bonding material from the same manufacturer for each product. Bonding material adoption can affect marginal microleakage. Further studies to analyze the effects of bonding material on microleakage in bulkfill composite is recommended.

Conclusion

In reply to the assumptions of the current study, it can be concluded that microleakage of all three composites in dentin edge was significantly more than the enamel edge. However, the three composites were different in performance and 3M Flowable Bulkfill had the best performance but in marginal adaptation with class V cavities, flowable bulkfill composites did not have any significant statistical advantage compared to conventional composites.

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