EFFECT OF COMPOSITE PREHEATING AND PLACEMENT TECHNIQUES ON MARGINAL INTEGRITY OF CLASS V RESTORATIONS

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ABSTRACT

INTRODUCTION: Different placement techniques of resin-based composite (RBC) systems have been developed to improve the marginal adaptation and reduce microleakage. These techniques included preheating and vibration of resin composite materials.

OBJECTIVES: The current study aimed to investigate the effect of preheating and placement techniques on microleakage and marginal gap formation of class V composite restorations.

MATERIALS AND METHODS: A total of eighty sound extracted human molars were used in this study. Standard class V cavities were prepared on their buccal surfaces (4mm mesiodistally, 3mm occlusocervically, and 3 mm pulpal depth). The teeth were divided into 4 groups (n=20): **Group I:** restored with Filtek bulk fill flowable composite, **Group II:** restored with Filtek bulk fill composite after it was heated to 60°C using Calset device, **Group III:** restored with Filtek bulk fill composite adapted with a vibrating instrument (Compothixo), **Group IV:** restored with Filtek Z350 XT. Specimens were light cured, thermocycled between (5 ºC and 55 ºC in water) and marginal gaps assessment was measured under a stereomicroscope and measured in micrometers. Then teeth were dyed with 0.5% basic fuchsin dye for 24 hours. The dyed specimens were sectioned in the buccolingual direction and evaluated for microleakage (dye penetration) using a stereomicroscope.

RESULTS: For marginal gap assessment, results revealed a significant difference between the tested groups, where flowable bulk‑fill showed the lowest statistically significant marginal gaps compared to other groups at the occlusal and gingival margins (p<0.05). For the microleakage test, the groups showed more microleakage at gingival margins compared to occlusal margins, flowable bulk- fill and preheated bulk -fill showed the lower microleakage scores among groups.

CONCLUSIONS: None of the placement techniques produced gap-free margins. Flowable bulk-fill composite and preheated composite preserved better marginal integrity and reduced microleakage.

KEYWORDS: Dental Composite, Preheating, Microleakage, Vibration, Marginal gap.

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INTRODUCTION

Dental composite resins are the most frequently used direct tooth-colored restorative materials restoring cervical lesions. The high viscosity and stickiness of the highly filled composite makes the adaptation of the material to the preparation walls difficult and may leave unwanted voids that can lead to poor marginal integrity, especially for cavities with high configuration factor such as class V cavities (1).

Different techniques and resin-based composite systems have been developed to improve the marginal adaptation and mechanical properties of the composite restorations. Many of these techniques involve variations of material placement. These have included incremental placement, usage of cavity liner, pre-heating of RBC materials and bulk placement techniques (2).

Warming or preheating composite before photopolymerization was introduced that decreasing viscosity and increase the flow of resin composite without undermining mechanical properties (3). It has been reported that increasing composite temperature up to 60°C might enhance the degree of conversion on the top and in 2mm of the bottom surfaces which minimized the amount of curing light needed (4).

However, the higher double bond conversion of pre-heated composites is also accompanied by increased volumetric shrinkage, which might lead to greater shrinkage stress development during polymerization (5).

Bulk-fill flowable composite resin, with significant flow and low polymerization shrinkage, has been marketed (6). Flowable composites, with their low elastic modulus, compete with stress development, potentially helping to maintain the marginal seal of the restoration. Moreover, flowable composites are readily workable and adaptable to the cavity walls and their use can reduce marginal defects in restorations (7).

Placement of composite resins can be also achieved faster by using vibrating instruments. Vibration lowers the viscosity of the resin, allowing the material to flow and easily adapt to the cavity walls without air pores, in a similar way as a flowable composite (8).

The null hypothesis of this study was that the bulk-fill composite that was preheated or adapted with a vibrating instrument would have a comparable adaptation and microleakage of incrementally placed composite resin materials.

MATERIALS AND METHODS

Materials used in the present study summarized in table (1).

Preparation of the test specimen

A total of eighty extracted sound human molars were prepared with a standard class V cavity on their buccal surfaces (4mm mesiodistally, 3mm occlusocervically, and 3 mm pulpal depth), a Tofflemire metal band with window of (4 mm mesiodistal X 3 mm occlusal gingivally) was held around the tooth by a Tofflemire retainer with the lower border of the band placed on a line drawn on the cement-enamel junction, and then a thin permanent marker was used to mark the cavity outline (the lower border of the band on the cement-enamel junction but the lower border of the window was 1mm above cement-enamel junction) (9). Cavities were prepared by using a plain fissure carbide bur size 0.9 (Komet H21 3140 1 Lemgo, Germany) with with 4 mm cutting tip, mounted on a high-speed hand-piece under copious water cooling. To standardize the cavity depth at 3 mm, a closely fitting Teflon stopper was added to the shank of each bur and positioned on the burs at 3mm depth. The bur was replaced by a new one every 4 cavity preparations.

Table (1): Materials trade name, composition and manufacturers were used in this study.

Material	Type	Composition	Manufacturer
Filtek™ bulkfill composite	Light cured Bulk fill nano composite	Monomer: AUDM, UDMA, DDDMA Fillers: Aggregated zirconia/silica cluster filler (comprised of 20 nm silica and 4 to 11 nm zirconia particle), agglomerate 100 nm Ytterbium trifluoride (YbF3)	3M,ESPE,St. Paul, MN, USA
Filtek™ bulkfill flowable composite	Light cured bulk fill flowable composite (Micro hybrid)	Monomer: BisGMA,UDMA,BIS-EMA and Procrylate resins. Fillers: Zirconia and silica.01-3.5µ,ytterbium trifluoride0.1-5.0µ Filler content: (wt%/vol%):64.5%/42.5%	3M ESPE, St. Paul, MN, USA
Filtek™ Z350XT Universal composite	Light cured Universal nano composite	Monomers: BISGMA, UDMA TEGDMA, BIS-EMA Fillers: Aggregated zirconia (0.6-1.4µm) and sio2 (20nm)78.5/59.5%m/v	3M,ESPE,St. Paul, MN, USA

The LED 55 TPC curing unit (851 S. Lawson ST City of industry, CA91748 USA) (light intensity 1200Mw/cm2) was used to cure the adhesive and the composite resin.

The teeth were randomly divided into four groups of twenty teeth each (n=20), according to the technique used for tooth restoration. As follows:

Group I: Teeth were restored with a bulk-fill flowable composite (FiltekTM bulk-fill flowable).

Group II: Teeth were restored with bulk-fill composite (Filtek™ bulk-fill (after heating to 60°C using Calset (Calset composite warmer AdDent Inc, Danbury, Ct, USA) device.

Group III: Teeth were restored with bulk-fill composite (Filtek™ bulk-fill), after using the modeling instrument

(Compothixo) (Compothixo KerrHawe SA-Via Strecce 4-6934 Bioggio/Switzerland).

Group IV: Teeth were restored with nano-filled universal composite (Filtek™ Z350 XT) by incremental build up.

Before composite application, enamel and dentin were etched with 35% phosphoric acid (Scotch bond Etchant) (3M, ESPE, Saint Paul, MN, USA), for 15 seconds, rinsed with water for 15 seconds, then excess water was removed by using a mini-sponge.

The adhesive system (Adper™ Single Bond 2) was applied according to the manufacturer□s instructions to all cavity walls, using a disposable applicator supplied with the system, then light cured for 10s with LED55 TPC light curing unit.

For Group I, bulk-fill flowable composite was dispensed at the deepest part of the cavity keeping tip close to the floor of the cavity. At the completion of dispensing, the tip was wiped against the cavity wall withdrawing from the operative field, then light cured for 20 seconds. For Group II, Composite syringes were placed in the Calset device before placement into the cavities. The heating unit was placed very close to the cavity to be restored, after removing the composite resin from the Calset, placed immediately in bulk to fill the prepared cavity using a plastic filling instrument, then light cured for 20 seconds.

For Group III, the composite material was placed in bulk to fill the prepared cavity using a plastic filling instrument then used the compothixo oscillating packing instrument. The oscillation energy (140 Hz) was applied for 30 seconds, during which the composite was adapted to all the cavity walls, then light cured for 20 seconds. For Group IV, three oblique increments was placed using a plastic filling instrument, The first increment was placed on the axial and mesial cavity walls, the second on the axial and distal cavity walls, and the last increment completely filled the cavity, each increment was light cured for 20 seconds.

For all groups, the composite restoration was finished using diamond finishing burs (Diatech Dental AC, Heerbrugg, Switzerland) and polished using aluminum oxide (soflex) discs (3M ESPE Dental Products, St. Paul, MN, USA) used as manufacturer instructions.

Marginal gap assessment

The marginal gap (the distance between the outer surface of the cavity wall and the restoration) of all the restored teeth (n=80) were measured at the occlusal and gingival margins using a stereomicroscope (Olympus model no. SZ11. Japan), the specimens were placed on the microscope platform then light was adjusted. A digital camera mounted on the microscope was used to capture the area of the restoration at a magnification (40x). Digital images were then transferred to a computer system. They were analyzed using the image analysis software (cell□A). Three points at the occlusal margin and three points at the gingival margin were measured in μm. The mean was obtained by averaging the values for each margin (10). Figure (1).

Microleakage testing

After marginal gaps were measured, all the restored teeth (n=80) prepared for the microleakage test, then the root apices of the teeth were sealed with sticky wax. The whole

surface of each tooth was coated with two layers of a nail polish 1mm away from the restoration margins could eliminate microleakage from areas other than the restoration margins that could lead to false positive results (11). The teeth were immersed in 0.5% basic fuchsine dye solution for 24 hours at room temperature.

To measure the extent of microleakage; teeth were sectioned longitudinally through the restorations in a buccolingual direction using a diamond disc. The sectioned teeth were evaluated for microleakage with a stereomicroscope at (40x) magnification and scored from 0 to 3 depending on the extent of dye penetration for the occlusal and the gingival walls separately (12). The microleakage which had occurred at the occlusal and gingival margins at the tooth and restoration interface was scored as followed:

0- No dye penetration (no microleakage).

1- Dye penetration involving half or less of the occlusal/gingival wall.

2- Dye penetration involving more than half of the occlusal/gingival wall.

3- Dye penetration involving the axial wall.
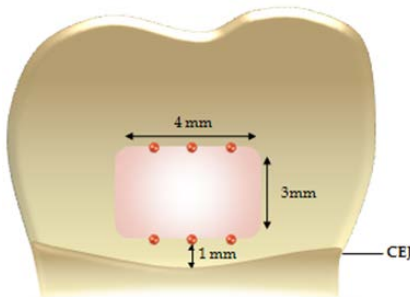
Figure (1): The location of the points for marginal gap measurements at the occlusal and gingival region.

STATISTICAL ANALYSIS
Data were statistically analyzed using IBM SPSS software package version 20.0.

Quantitative data were described using mean and standard deviation for normally distributed data.

For normally distributed data, independent t-test was used for a comparison between two independent population while F-test (ANOVA) used to analyze more than two population.

The significance test results were quoted as two-tailed probabilities. Significance of the obtained results was judged at the 5% level.

RESULTS
Results of marginal gap assessment
For marginal gap measurements at the occlusal margins. The means of occlusal marginal gaps in micrometers for all groups and the descriptive statistical analysis are shown in Table (2). The highest mean marginal gaps were for Group III and IV (75.89 ± 8.64 and 75.714 ± 8.81 µm respectively), followed by Group II (67.74 ± 7.13 µm). The lowest mean was recorded for Group I (57.79 ± 5.98 µm).

Anova F-test revealed a significant difference between all the test groups (p= 0.001).

For marginal gap measurements at the gingival margins. The results for the gingival marginal gaps revealed that Group IV and Group III showed the highest

mean marginal gaps values (81.89 ± 6.32 and 81.47 ± 6.87 µm respectively). The lowest gap mean was recorded in Group I and Group II (70.16 ± 6.64 and 70.42 ± 6.74 µm respectively). Table (2).

Anova F-test revealed a significant difference between the test groups (p=0.012).

Table (2): Comparison of marginal gap (µm) measurements at the occlusal margins and gingival margins in the different studied groups.

Occlusal margins	Group I	Group II	Group III	Group IV
Min	50	60	63	61
Max	70	80	89	90
Mean	57.79	67.74	75.89	75.74
S.D.	5.98	7.13	8.64	8.81
ANOVA P	25.63 0.001**			
P1		0.003**	0.001**	0.001**
P2			0.021*	0.011*
P3				0.652
Gingival margins				
Min	60	60	70	70
Max	80	80	90	90
Mean	70.16	70.42	81.47	81.89
S.D.	6.64	6.74	6.87	6.32
ANOVA P	18.53 0.012*			
P1		0.981	0.028*	0.027*
P2			0.018*	0.012*
P3				0.65

P1 comparison between Group I and other groups.
P2 comparison between Group II and both Group III and IV
P3 comparison between Group III and IV.
P is significant if <0.05
* level of significant at 0.05
** Level of highly significant at 0.01

Results of microleakage assessment
The means of occlusal microleakage scores for all groups and the descriptive statistical analysis are shown in Table (3). The highest mean microleakage scores were recorded for Group III (0.70 ± 0.66), followed by Group IV (0.60 ± 0.50). The lowest mean was recorded for Group I and Group II (0.55 ± 0.51and 0.55 ± 0.60 respectively).
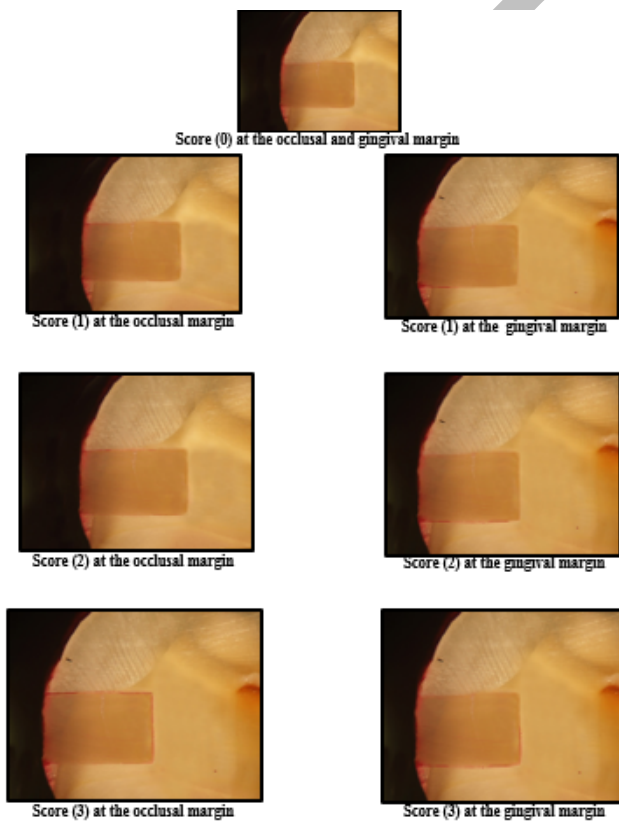
Anova F-test proved no significant difference among the four groups with respect to microleakage level at the occlusal margins (p=0.069).

The mean values for microleakage scores at the gingival margins are shown in Table (3). Descriptive data analysis revealed that the highest mean microleakage scores were recorded for Group III and Group IV (1.15 ± 0.80 and 1.25 ± 1.16 respectively), followed by Group II (0.95 ±1.15), the lowest mean values were recorded for Group I (0.70 ± 0.80).

Anova F-test revealed a significant difference between the test groups (p=0.001). Representative microleakage scoring from 0-3 at occlusal and gingival margins are shown in Figure (2).

Table (3): Comparison of microleakage scoring criteria at the occlusal margins and gingival margins in the different studied groups.

Microleakage scoring Criteria at occlusal margin	Group I		Group II		Group III		Group IV	
	No.	%	No.	%	No.	%	No.	%
0	9	45.0	10	50.0	8	40.0	8	54.5
1	11	55.0	9	45.0	10	50.0	12	45.5
2	0	0	1	5	2	10	0	0
3	0	0	0	0	0	0	0	0
Min. – Max.	0.0 – 1.0		0.0 – 2.0		0.0 –2.0		0.0 – 1.0	
Mean ± SD.	0.55 ± 0.5		0.55 ± 0.60		0.70 ± 0.66		0.60 ± 0.5	
Microleakage scoring Criteria at gingival margin								
0	10	50.0	10	50.0	4	20.0	7	35.0
1	6	30.0	4	20.0	10	50.0	5	25.0
2	4	20.0	3	15.0	5	25.0	4	20.0
3	0	0	3	15.0	1	5.0	4	20.0
Min. – Max.	0.0 –2.0		0.0 – 3.0		0.0 –3.0		0.0 – 3.0	
Mean ± SD.	0.70 ± 0.80		0.95 ± 1.15		1.15 ± 0.81		1.25 ± 1.16	

Score (0) at the occlusal and gingival margin

Score (1) at the occlusal margin   Score (1) at the gingival margin

Score (2) at the occlusal margin   Score (2) at the gingival margin

Score (3) at the occlusal margin   Score (3) at the gingival margin

Figure (2): Representative microleakage scoring from 0-3 at occlusal and gingival margins.

DISCUSSION

It has been known for many years that conventional restorative materials and techniques produce dental restorations that do not provide a complete marginal seal and numerous studies have demonstrated that leakage of fluid will occur between the filling and the prepared tooth surface (13). Marginal void formations are the leading causes of failure in resin-based restoration. The longevity of resin-based composite restorations is compromised when bonding between the resin and the interior cavity walls fails to prevent marginal microleakage (14).

In this study, preheated bulk-fill was used in the form of syringes. It is estimated that when a composite is heated up to 60°C and removed from the device, its temperature drops around 35–40% after the 40s (15). The heating unit was placed very close to the cavity to be restored to provide allow quick application and to allow the minimum amount of heat to be dissipated during manipulation. This comes in agreement with Daronch et al. (16) in 2006 as many authors advised the clinician to work with the composite quickly in order to ensure the least temperature drop possible and achieve the best clinical performance (17). It found that preheated resin composite to 54°C or 68°C increased the intra-pulpal temperature than the composite that was applied at room temperature but not to the critical level. The elevation was 1.5°C-2°C (18).

In the current study, the packing instrument that condenses the material by vibration was used to pack resin composite. The principle of this technique assumes that vibration lowers the viscosity of the resin, allowing the material to flow and easily adapt to the cavity walls in a similar way as a flowable resin composite (19).

For the marginal gap assessment, the results of the present study demonstrated that there were statistically significant differences in the mean micro gaps width among the experimental groups. The lowest mean marginal gaps were obtained on both occlusal and gingival margins of cavities restored with a bulk-fill flowable composite (Group I). This may be attributed to the degree of fluidity of the composite when applying to the cavity, which allows better adaptation to the cavity walls. This was in agreement with the work of Orlowski et al. (20), who compared the adaptation of flowable and sculptable bulk-fill Composite resins, Their results showed that the flowable bulk-fill composites have better adaptability to the cavity walls.

Nonetheless, the results of the current study were in disagreement with the work of Jung et al. (21), who found that bulk fill resin-based composites showed better marginal adaptation than flowable bulk-fill resin-based composites. Their explanatation was that the lower level of polymerization shrinkage and polymerization shrinkage stress in bulk-fill resin-based composites seems to contribute to this finding because it would induce less polymerization shrinkage force at the margin. Flowable bulk -fill resin-based composites with lower flexural modulus may not provide an effective buffer to occlusal stress when they are capped with regular resin-based composites.

In the current study, preheating of the filtek bulk-fill composite resin (Group II) presented better marginal adaptation compared to both the same bulk-fill composite that was placed using the compothixo packing instrument (Group III) and the conventional composite (Filtek Z350 XT) that was placed by layering technique (Group IV). This could be explained that increasing the composite temperature, decreases the viscosity of the materials and enhance molecular mobility as a result of higher thermal energy, resulting in additional polymerization. This improves the placement and adaptation of the material within the cavity walls. It was claimed that the flowable characteristics of the preheated highly filled composite are similar to those of flowable composite (5,22).

The results of the current study were in agreement with Taraboanta et al. (23), who found that pre-heating of resin-based materials improves the adaptation of these materials to tooth structures. In contrast to our results, Elsayad (24), found that preheating resin composite to very high temperatures, such as 68°C, will not improve the marginal adaptation and will cause considerable tooth deformation (in the form of cuspal movement and gap formation), the author claimed that when the temperature was elevated, a more rapid photopolymerization occurred. These high reaction rates may lead to higher stress formation and faster development of the gel point, providing detrimental effects to the integrity of the resin/tooth interfacial bond.

None of the techniques for composite placement that were investigated were able to eliminate microleakage completely at both enamel and dentine margins, in the current study, microleakage was found to be more in the gingival margins than the occlusal margins and this could be explained by the thinner structure of enamel at the cervical area, which may become more susceptible to leakage. The greater thickness of enamel occlusally allows better penetration of the adhesive system, the ability of the adhesive resin to infiltrate enamel and dentin depends on the amount of surface free energy of dental substrate, which is directly proportional to the level of mineralization and indirectly proportional to the percentage of organic tissue (the low organic content of enamel compared with dentin), this clearly explains the higher predictability of adhesion to enamel compared with dentin forming the stronger micromechanical bond with the composite (25). Another reason for the increased microleakage at the gingival margins of class V restorations would be the frequent occurrence of the prismless enamel at the gingival margins of permanent teeth, the extent of resin penetration into prismless enamel is limited, this may not provide as an effective barrier to dye penetration (26).

The present study showed that the flowable bulk-fill composites (Group I) were obtained the lowest microleakage scores on both occlusal and gingival walls. This might be due to the low elastic modulus and high wettability of flowable composites that causes this kind of material to absorb the shrinkage stress during the polymerization making them act as stress breaker. Also, their low modulus of elasticity increases their ability to be more flexible with a tooth than stiffer materials, making them suitable to be used with class V restorations (27,28).

These results match with the result of Scotti et al. (29), who found that bulk-fill flowable composite provided the highest marginal seal in gingival margins among groups, this could be attributed to the lower stresses (stress is determined by volumetric shrinkage and the elastic modulus of the material, flowable composites, with their low elastic modulus, compete with stress development, potentially helping to maintain the marginal seal of the restoration) of the bulk-fill flowable composite and its high wettability that could provide better marginal adaptation to the cavity walls. Also, Nagy et al. (30), found that flowable bulk-fill showed a lower degree of microleakage than posterior bulk-fill and conventional composite. In contrast to our results, Arslan et al. (31), demonstrated that the microleakage was not affected by the application of either conventional flowable or bulk-fill flowable composites and this could be attributed to the

difference in methodology used, as they used bulk-fill flowable composites (SDR) as intermediate material not as a restorative material.

In the current study, preheating the high viscosity bulk-fill composite (Filtek bulk -fill) showed less microleakage scores compared to both the same bulk-fill composite that was placed using the compothixo packing (140 Hz) instrument and the conventional composite (Filtek Z350 XT) that was placed by incremental technique. This could be attributed to the preheated composite may not increase polymerization-induced shrinkage forces, decrease resin composite viscosity, enhance radical mobility and polymer chain relaxation, and thus increased stress relief compared to room-temperature composite, compensating the effect of the higher volume contraction (23).

The results of the current study were in agreement with Wagner et al. (32) and Didron PP et al. (33), found that preheating of composites to 60°C resulted in significantly less microleakage at the cervical margin. Also, Yang et al. (34), concluded that composites can be warmed to mimic flowable composites in achieving better adaptability to the cavity walls by reducing viscosity and thereby reducing microleakage.

This was in contrast with Karaarslan et al. (35), who found no significant differences among the preheated groups (Composite preheated to 37ºC, 54ºC and 68ºC). In addition, Deb S et al. (36), found that although marginal adaptation may be better because of the enhanced flowability of preheated resin composites, shrinkage may also be greater because of higher monomer conversion. They highlighted that increased shrinkage may counteract the improved adaptation achieved by warming composites, leading to no difference in microleakage of composites cured under different temperature conditions (The flow properties and microleakage were evaluated at 22 °C and 60 °C).

Another important result in this study is that bulk -fill composite that adapted with compothixo (Group III) and the conventional composite adapted by incremental techniques (Group IV) showed the highest microleakage scores on occlusal and gingival margins among the tested groups. In Group III with the compothixo packing instrument, the vibration seemed to make the material more adherent to the instrument and more difficult to apply due to the high viscosity of bulk fill material leading to the poor adaptation between restoration and cavity walls. A variety of studies have shown that lower viscosity of composites can improve adaptation and reduce microleakage (18-22). In contrast to our results, Eunice et al (9), evaluated the marginal microleakage with SonicFillTM. Their study showed that the high oscillation energy had no effect concerning the microleakage of packable composite resin, where no statistically significant difference was found between the incremental and oscillation packing methods used in their study, It found that the polymerization shrinkage is similar in both methods.

In Group IV with the packable nano-filled Filtek Z350 XT composite showed higher microleakage scores. This could be due to that adaptation of the composite to the margins and walls of the cavity is not perfect as more layers of material have to be used, each being applied, condensed, shaped and polymerized (37). This was in

agreement with Jaganath et al. (38), who found that incremental Filtek Z350 XT showed the highest interfacial gap formation among the tested groups (bulk-fill flowable composite(SDR) and nano-hybrid flowable composite). This was in contrast with the work of Habib et al. (39), who stated that no significant difference was found between the microleakage scores of the incremental Filtek Z350 XT compared to bulk-fill composites placed using different restorative techniques (Filtek bulk-fill, Filtek bulk-fill flowable and SonicFillTM composites). Their explanation was that the the Filtek bulk-fill composite is mainly based on UDMA while the incremental Z350 XT composite contains BisGMA in addition to the UDMA. The UDMA is known to have a higher molecular weight compared to BisGMA. This relatively high molecular weight may have decreased the overall polymerization shrinkage, thus decreased the interfacial stresses and the microleakage (40).

CONCLUSION

The null hypotheses of the study were rejected. Within the limitations of this in vitro study, it can be concluded that none of the placement techniques produced gap-free margins. Preheated composite and flowable bulk fill composite improved marginal adaptation and decreased microleakage compared to incremental placement of composite or by using a vibrating instrument.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

1- Dionysopoulos D, Papadopoulos C, Koliniotou-Koumpia E. The evaluation of various restoration techniques on internal adaptation of composites in class V cavities. Int J Biomater. 2014;148057.
2- Ilie N, Kessler A, Durner J. Influence of various irradiation processes on the mechanical properties and polymerisation kinetics of bulk-fill resin based composites. J Dent. 2013;41:695-702.
3- Daronch M, Rueggeberg FA, Moss L, de Goes MF. Clinically relevant issues related to preheating composites. J Esthet Restor Dent. 2006;18:340-50.
4- Fróes-Salgado NR, Silva LM, Kawano Y, Francci C, Reis A, Loguercio AD. Composite pre-heating: Effects on marginal adaptation, degree of conversion and mechanical properties. Dent Mater. 2010;26:908-14.
5- Daronch M, Rueggeberg FA, De Goes MF. Monomer conversion of pre-heated composite. J Dent Res. 2005;84:663-7.
6- Christensen GJ. Advantages and challenges of bulk fill resins. Clin Rep. 2012,5:1-2.
7- Agarwal RS, Hiremath H, Agarwal J, Garg A. Evaluation of cervical marginal and internal adaptation using newer bulk fill composites: An in vitro study. J Conserv Dent. 2015;18:56-61.
8- Iovan G, Stoleriu S, Moldovanu A, Morogai S, Andrian S. SEM study of the interface between the cavity wall and composite resin in cavities filled using vibration. Int J Med Dent. 2011;1:254-8.
9- Eunice C, Margarida A, João C, Filomena B, Anabela P, Pedro A, et al. 99mTc in the evaluation of microleakage of composite resin restorations with SonicFillTM. An in vitro experimental model. OJST. 2012;2:340-7
10- Casselli DSM, Faria-E-Silva AL, Casselli H, Martins LRM. Marginal adaptation of class V composite restorations submitted to thermal and mechanical cycling. J Appl Oral Sci. 2013;21:184-9.
11- Ahmed W, El-Badrawy W, Kulkami G, Prakki A, El-Mowafy O. Gingival microleakage of class V composite restorations with fiber inserts. J Contemp Dent Pract. 2013;14:622-8.
12- Yikilgan İ, Akgul S, Özcan S, Bala O, Ömürlü H. An in vitro evaluation of the effects of desensitizing agents on microleakage of Class V cavities. J Clin Exp Dent. 2016;8:e55-9.
13- Alani AH, Toh CG. Detection of microleakage around dental restorations: a review. Oper Dent. 1997;22:173-85.
14- Van Nieuwenhuysen JP. D Hoore W, Carvalho J, Qvist V. Long term evaluation of extensive restorations in permanent teeth. J Dent. 2003;31:395-405.
15- Arslan S DS, Zorba YO, Ucar FI, et al. The effect of pre-heating silorane and methacrylate-based composites on microleakage of class V restorations. Eur J Gen Dent. 2012; 1: 178-182.
16- Daronch M, Rueggeberg FA, De Goes MF, Giudici R. Polymerization kinetics of pre-heated composite. J Dent Res. 2006;85:38-43.
17- Muñoz CA, Bond PR, Sy-Muñoz J, Tan D, Peterson J. Effect of pre-heating on depth of cure and surface hardness of light-polymerized resin composites. Am J Dent. 2008;21:215-22.
18- El-Deeb HA, Abd El-Aziz S, Mobarak EH. Effect of preheating of low shrinking resin composite on intrapulpal temperature and microtensile bond strength to dentin. J Adv Res. 2015;6:471-8.
19- Iovan G, Stoleriu S, Moldovanu A, Morogai S, Andrian S. Sem study of the interface between the cavity wall and composite resin in cavities filled using vibration. Int J Med Dent. 2011;1:254-8.
20- OrBowski M, Tarczydło B, Chałas R. Evaluation of marginal integrity of four bulk-fill dental composite materials: In vitro study. Sci World J. 2015;701262.
21- Jung JH, Park SH. Comparison of polymerization shrinkage, physical properties, and marginal adaptation of flowable and restorative bulk fill resin-based composites. Oper Dent. 2017;42:375-86.
22- Knight JS, Fraughn R, Norrington D. Effect of temperature on the flow properties of resin composite. Gen Dent. 2006;54:14-6.
23- Taraboanta, Stoleriu S, Iovan G, Moldovanu A, Georgescu A, Negraia MR, et al. Evaluation of Pre-heating Effects on Marginal Adaptation of Resin-based Materials. Mater Plast. 2018;55:238.
24- Elsayad I. Cuspal movement and gap formation in premolars restored with preheated resin composite. Oper Dent. 2009;34:725-31.
25- Ilie N, Bucuta S, Draenert M. Bulk-fill resin-based composites: an in vitro assessment of their mechanical performance. Oper Dent. 2013;38:618-25.
26- Retief DH, Woods E, Jamison HC. Effect of cavosurface treatment on marginal leakage in class V composite resin restorations. J Prosthet Dent. 1982;47:496-501.

27- Awliya WY, El-Sahn AM. Leakage pathway of Class V cavities restored with different flowable resin composite restorations. Oper Dent. 2008;33:31-6.

28- Rodrigues Junior SA, Zanchi CH, Carvalho RV, Demarco FF. Flexural strength and modulus of elasticity of different types of resin-based composites. Braz Oral Res. 2007;21:16-21.

29- Scotti N, Comba A, Gambino A, Paolino DS, Alovisi M, Pasqualini D, et al. Microleakage at enamel and dentin margins with a bulk fills flowable resin. Eur J Dent. 2014;8:1-8.

30- Nagy IO, El‑Sayed HY, Shalaby ME. Evaluation of marginal seal of different composite restored class V cavity preparations with different cavosurface margins. Tanta Dent J. 2018;15:140.

31- Arslan S, Demirbuga S, Ustun Y, Dincer AN, Canakci BC, Zorba YO. The effect of a new-generation flowable composite resin on microleakage in Class V composite restorations as an intermediate layer. J Conserv Dent. 2013;16:189-93.

32- Wagner WC, Aksu MN, Neme AM, Linger JB, Pink FE, Walker S. Effect of pre-heating resin composite on restoration microleakage. Oper Dent. 2008;33:72-8.

33- Didron PP, Chrzanowski, W, Ellakwa A. Effect of temperatures on polymerization stress and microleakage of class v composite restorations. OJCM. 2013;3:107-12.

34- Yang JN, Raj JD, Sherlin H. Effects of preheated composite on micro leakage-an in-vitro study. J Clin Diagn Res. 2016;10:ZC36-8.

35- Karaarslan ES, Usumez A, Ozturk B, Cebe MA. Effect of cavity preparation techniques and different preheating procedures on microleakage of class V resin restorations. Eur J Dent. 2012;6:87-94.

36- Deb S, Di Silvio L, Mackler HE, Millar BJ. Pre-warming of dental composites. Dent Mater. 2011;27:e51-9.

37- Bagis YH, Baltacioglu IH, Kahyaogullari S. Comparing microleakage and the layering methods of silorane‑based resin composite in wide class II MOD cavities. Oper Dent. 2009;34:578-85.

38- Jaganath BM, Krishnegowda SC, Rudranaik S, Madanan S, Kurup NB, Manjula CG. Influence of composite insertion techniques (bulk fill and incremental nanofilled technique) on adaptability to the pulpal floor and interfacial gap formation. Int J Prev Clin Dent Res. 2017;4:1-7.

39- Habib ANA, Waly GH. The degree of conversion and class II cavity microleakage of different bulk fill composites placed with different restorative techniques. FDJ. 2018;4:231-8.

40- Lempel E, Czibulya Z, Kovács B, Szalma J, Tóth Á, Kunsági-Máté S, et al. Degree of conversion and BisGMA, TEGDMA, UDMA elution from flowable bulk fill composites. Int J Mol Sci. 2016;17:pii: E732.