Original article

Influence of Different Placement Techniques of Bulk-fill Resin Composite on Microleakage of Class II Cavity Preparation

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ABSTRACT

Aim: To evaluate the microleakage at the gingival seat of the class II cavity restored with bulk-fill resin composite using different placement techniques.
Materials and Methods: Two standardized class II cavities (MO and DO) were prepared in forty sound extracted human premolars. The cervical margin of the proximal box is located at 1 mm occlusal to the cementoenamel junction (CEJ). The prepared teeth were divided into four groups of 10 teeth each (n=20 cavities) and restored with Tetric N-Bond total-etch adhesive, followed by resin composite, Tetric N-Ceram Bulk-fill placed in four different techniques: GpI; as bulk-fill in a single increment, GpII; horizontal layering, GpIII; oblique (wedge-shaped) layering, GpIV; vertical layering. All restored teeth were stored in distilled water for 24h at 37ºC, thermocycled, and then soaked in 2% methylene blue dye for 24h. Teeth were then sectioned for microleakage evaluation using a stereomicroscope. Data were collected and statistically analyzed. Two specimens from each group were selected at random and examined under a scanning electron microscope (SEM) for marginal adaptation of restoration.
Results: No statistically significant differences in the microleakage score were observed between the four placement techniques ($P=0.610$). However, bulk placement had the highest mean and median score (3.0 ± 1.45&4). The horizontal, oblique, and vertical techniques had lower scores than bulk placement (2.30 ± 1.81, 2.6 ± 1.66, 2.45 ± 1.61) respectively.
Conclusions: Microleakage could not be eliminated by any of the tested placement techniques. Incremental placement techniques showed a lower score of microleakage compared with the bulk placement. The horizontal layering of bulk-fill composite showed the best results in terms of the marginal seal with tooth structure.

Keywords: Microleakage, Class II cavity, Bulk-fill composites, placement techniques.

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INTRODUCTION

Resin composites are widely used tooth-colored restorative materials in dentistry owing to their ability to replace the biological tissue in both appearance and function.[1] However, the suitability of these materials has been limited by its inherent polymerization shrinkage,[2] that compromises the integrity of the resin composite-tooth interface leading to gap formation between the cavity walls and the restoration.[3] This implies a clinically undetectable passage of bacteria, fluids, molecules from the oral cavity to the tooth structure known as micoleakage causing secondary caries and failure of the restoration.[4, 5]

Microleakage is one of the most frequent happenstance problems in posterior composite restorations especially in class II cavity preparations at the gingival seat which create a great challenges to the dental surgeons. This is due to difficulties in restoration technique, curing process and continuous exposure to subclavicular fluid,[6] particularly when the cervical margin of the preparation in the dentin.[7] Microleakage could be the outcome of several clinical factors that accompanied by increased polymerization shrinkage stress such as the high C-factor,[8] light-curing scenarios,[9] and variety of placement techniques of resin composites.[10]

To minimize the shrinkage stress, and consequently to decrease the microleakage with improvement in the marginal integrity and durability of resin composite restorations several approaches have been introduced such as; modification in material's formulations for properties optimization, the use of liner or base,[4] and incremental layering technique for placement of resin composite.[11]

Regarding modification in material formulations, a new category of resin-based composites (RBCs) called ''Bulk-fill'' composites have been introduced to dental practitioners.[12] These materials are claimed to offer a single increment placement ranging from 4-5 mm thickness instead of the conventional 2 mm increment.[12] This makes the material simple to use due to the decrease in the number of clinical steps, and quicker working time. In addition, literature reported that bulk-fill composites produce less shrinkage stress and cuspal flexure in standard class II cavities,[13] and preparation of high C-factor design while maintaining a high degree of cure.[10]

The incremental layering technique has been accepted as the gold standard for the placement of resin composite restorations.[14] This technique included packing the material incrementally into the cavity preparation, thus the contraction stress that occurred on one increment could be compensated by the next one.[15] In addition, several studies reported that the direction of the composite increment placed in the cavity showed great influences on the shrinkage stresses and microleakage.[4, 14, 15] The horizontal placement technique has been reported to increase the shrinkage stresses between the opposing cavity walls.[4] The oblique (wedge-shaped) layering technique reduces the C-factor and limits the development of contraction forces between opposing walls and hence decreases the polymerization shrinkage stresses.[16, 17] Vertical layering technique reduces the gap formed at the gingival margin, hence reduces postoperative sensitivity and secondary caries.[18] Some studies found no influence of placement techniques of composite resin on microleakage.[19, 20] Whereas other investigators found that the diagonal/oblique layering technique had the most leak-free margins when the proximal box ended on enamel.[21] Other investigators reported better results with the vertical layering technique compared to oblique layering.[22] On the other hand not much information is available on the effect of using various incremental placement techniques of bulk-fill composites on microleakage. Therefore, this *in vitro* study was conducted aimed at evaluating the marginal microleakage at the gingival seat of class II cavity prepared at 1mm occlusal to the cementoenamel junction (CEJ) restored with Bulk-fill composite resin packed in the cavity preparations using four different placement techniques.

MATERIALS AND METHODS:

The materials used in this study were one commercial bulk-fill resin composite; a Tetric N-Ceram bulk-fill, and one universal bonding system; Tetric N-Bond (Ivoclar Vivadent) with total etching technique as shown in Table 1.

Specimen preparation:

A total of 40 sound premolars teeth with neither carious lesion nor restoration, recently extracted for orthodontic reasons from several dental clinics were collected and used in this study. The extracted teeth were examined by an illuminated multi- powerhead magnifier to ensure that they were free of any defects. Then teeth were cleaned with an ultrasonic scaler and immersed in normal saline (0.9 % isotonic saline) till the time of use which was no longer than one month. The normal saline was changed every 3 days.[23]

The teeth were mounted vertically to a level of 2 mm below the cement enamel junction in readymade plastic containers used for ice quips of 2.5 cm height and 3cm diameter filled with fast setting dental stone. Using a number #245 fissure bur under air-water cooling high-speed handpiece, two standardized class II cavities (MO and DO) were prepared on mesial and distal aspects of each tooth. The cavity dimensions were 4.0 mm bucco-lingual, 2.0 mm axially, and a cervical margin located at 1mm occlusal to the cementoenamel junction (CEJ) with no enamel bevels. A new bur was used after every five cavities preparations.[23]A total of eighty Class II cavities with parallel walls, rounded internal line angles, and cervical margins established at 1 mm above the CEJ were prepared.

Table 1: Details of the materials used in the study

Product Name (Manufacturer)	Composition	Manufacturer instructions for use
Tetric N-Ceram Bulk Fill (Ivoclar Vivadent)	Dimethacrylate (19-21% wt). Inorganic filler (75-77% wt.), ~ 0.04-3 mm size. barium glass, prepolymer, yttriumtrifluoride, and mixed oxide.Additives catalysts, stabilizers, and pigments (<1.0% weight).	Applied in increment of 4 mm to the cavity walls. Light-cure for 20s. Additional polymerization from the buccal and palatal aspects after removal of the metal matrix.
Tetric N- Bond (Ivoclar Vivadent)	Phosphoric acid acrylate, HEMA, Bis-GMA, urethane dimethacrylate, ethanol, film-forming agent, catalysts, and stabilizers.	Apply a thick layer of Tetric N-Bond on the enamel and dentin gently using a microbrush. Remove the excess material by a gentle stream of air. Light-cure for 10s.

Restorative procedure:

Universal Tofflemire retainer (AISI 420 German stainless steel) with a metal matrix band of 0.05 mm (No 1001/30, Kerr Hawe SA, Bioggio, Switzerland) was applied for all cavities. The walls of each cavity were acid-etched with 37% phosphoric acid for 15s, rinsed with water for 15s, and dried with absorbent points. Tetric N-Bond, a light-curing, nano-filled single-component, dental adhesive (Ivoclar Vivadent, Liechtenstein) was applied to all prepared cavities with microbrush according to manufacturers' instruction, and then light-cured for 10s using a light-emitting diode (LED) curing unit (Elipar S10; 3M ESPE, St. Paul, MN, USA). The prepared teeth were then divided into four equal groups of 10 teeth each with a total of 20 cavities (n=20) for each placement technique. A Tetric N-Ceram Bulk-Fill composite (Ivoclar Vivadent) was packed according to placement technique as following: **GpI** (control): A bulk-fill (single increment) technique. **GpII:** Horizontal layering technique in three increments of less than 2 mm thickness each, starting from the gingival seat of the preparation towards the occlusal surface. **GpIII:** Oblique layering (wedge-shaped) technique in three increments in an oblique manner from wall to floor of the cavity. **GpIV:** Vertical layering technique in three layers packed vertically started from one wall (buccal) to the other wall (lingual) of the cavity.

Each increment was photo-activated with LED light-curing unit for 40s from the occlusal surface. Additional curing for 20s was performed on the proximal surface after removal of the matrix band and the retainer. The output of the light-curing unit was checked using a curing radiometer (Blue phase Meter II) to ensure a light intensity of at least 1000 mW/cm^2.

All the restorations were finished with a 30-fluted tungsten carbide finishing bur (Diatech Dental AC, Heerbrugg Switzerland) with water coolant to remove any excess material, particularly in the cervical region. This is followed by polishing with rubber points in a low-speed hand-piece and Soflex polishing discs to promote a smooth surface. Restored teeth were then stored in distilled water at 37°C for 24 hours before testing to ensure a complete polymerization process.

Thermocycling:

The specimens were subjected to thermal cycling to simulate the oral environment. The number of cycles used was 5000 cycles equivalent to 6 months. Dwell times were 25 seconds in each water bath thermocycling machine (Robota automated thermal cycle; BILGE, Turkey) with a lag time of 10 seconds. The low-temperature point was 5°C, and the high-temperature point was 55°C.[24]

Microleakage test:

The apex of each tooth was sealed by wax, and the remaining surfaces except for 1 mm around the restoration margins were covered with two layers of nail polish. The specimens were then immersed in a solution of 2% methylene blue dye (Supreme organization for drugs, Germany) for 24 hours at 37ºC. Subsequently, the teeth were cleaned of the dye using brushes and rinsing with water, then were sectioned mesio-distally with a low-speed diamond disc under water spray at 1 mm above the gingival seat perpendicular to the long axis of the tooth.[25] The dye penetration along the cavity walls (including axial and gingival margins) was assessed under a stereomicroscope (Nikon Eclipse E600, Tokyo, Japan) at X35 magnification. The image of the restoration was captured and transferred to a computer equipped with an image analysis software program (Image J 1.43U, National Institute of Health, USA), where the microleakage was assessed. The depth of dye penetration was analyzed based on the graded scale used in previous studies.[4, 19, 26] Score 0: No dye penetration, score 1: Dye penetration extending to 1/3rd of the cervical wall, score 2: Dye penetration extending to 2/3rd of the cervical wall, score 3- Dye penetration into the whole of the cervical wall, and score4: Dye penetration into the cervical wall and axial walls toward the pulp.

Marginal adaptation analysis using a scanning electron microscope (SEM):

For morphologic evaluation of the dentin/resin interfaces by SEM (JEOL, JSM-7610FPlus Field Emission SEM, Pillips, Holland) two teeth as representative specimens from each testing group were sectioned longitudinally perpendicular to the bonded surface using a low-speed diamond disc under copious water coolant. After surface polishing, teeth were immersed in 6 ml/liter hydrochloric acid (HCl) for 30 seconds to demineralize the minerals within the hybrid layer, then washed with water for one minute. The specimens were then immersed in 1% sodium hypochlorite (NaOCl) for 10 minutes to dissolve exposed collagen beneath the hybrid layer, and then thorough rinsing with water for 5 minutes. The specimens were dehydrated in ascending concentrations of alcohol, subjected to critical point drying, and then were gold-sputtered. The hybrid layer and the resin tags at dentin/resin interfaces were observed with SEM at a magnification of X1000.[27]

Statistical analysis was carried out using a distribution test to evaluate the proportions of microleakage scores within each testing group and within the overall study specimens. Kruskal Wallis test was used to compare microleakage across different techniques of bulk-fill composite resin. Additionally, the Mann Whitney U test was used to compare microleakage score by tooth surface.

RESULTS:

Results of the microleakage test:

Results of the study demonstrated that microleakage occurs in the four different placement techniques. Figure 1 shows the distribution of microleakage among the study specimens (80 restorations). No microleakage (score 0) was observed in less than a quarter of study specimens; 19 restorations (23.8%). On the other hand, nearly half of the specimens; 36 restorations (45%) demonstrated score 4, where the dye infiltrated up to the whole length of the gingival wall and along the axial wall. 15 restorations (18.8%) showeda score 3 of microleakage. Scores 1 and 2 were minimum and representing as 2(2.5%), and 8(10%) respectively.

Results of the study showed that packing of the composite with bulk technique as a single increment (GpI) demonstrated the lowest level of no microleakage (score 0); 3 restorations (15%), and the highest level of microleakage (score 4); 11 restorations (55%), followed by scores 3 (20%) and 2 (10%) (Figure 2). No microleakage was seen in 35% of the composite restorations placed with the horizontal layering technique (GpII). Score 4 was the most common pattern of microleakage in this group (40%) followed by scores 3 (20%), and score 2 (5%) respectively. Score 1 was not observed among this group (Figure 3). Oblique layering technique (GpIII) illustrated that 25% of the restoration showed no microleakage. Very similar to the former techniques, score 4 was the most prominent in this group and observed in 45% of the restorations, followed by score 3 (20%), and 2 (10%) respectively. Score 1 was not observed in this group (Figure 4).

Among the vertical layering technique (GpIV); 20% of the restorations exhibited no microleakage. However, similar to the former techniques, score 4 was the predominant type of microleakage; 40% of the restorations. On the other hand, unlike previous layering techniques, a score 1 was observed in 10% of restorations (Figure 5). To compare the proportions of no microleakage (score 0) in the four placement techniques; It can be observed that the horizontal layering technique demonstrated the least microleakage, whereas the bulk techniques showed the highest level of microleakage. Nevertheless, these differences were not statistically significant ($p=0.565$) (Figure 6).

Results of the Kruskal Wallis test (Table 2) revealed that there were no statistically significant differences in microleakage scores between the different placement techniques ($P=0.610$). However, the bulk technique had the highest mean and median for microleakage score (3.0 ±1.451 & 4). The incremental placement techniques show better results than the bulk placement technique regarding the microleakage score. Although the horizontal, vertical, and oblique techniques have a similar median score, the horizontal technique has the lowest mean score (Table 2). Results of the Mann Whitney U test revealed that there were no statistically significant differences for the overall mesial and distal restorations.

Table 2: Comparison of microleakage scores by different placement techniques (n=80)

Placement technique	Number of specimens	Mean score	SD	Median	Mode	P-value
Bulk (GpI)	20	3.00	1.451	4	4	0.610
Horizontal (GpII)	20	2.30	1.809	3	4	
Oblique (GpIII)	20	2.60	1.667	3	4	
Vertical (GpIV)	20	2.45	1.605	3	4	

Results of marginal adaptation analysis using a scanning electron microscope (SEM):

The SEM photomicrograph of the bonded resin/dentin interface of bulk placement specimens showed a thin hybrid layer with long and broken dentin resin tags arranged perpendicular to the interface with a continuous gap along with the interface (Figure 7-I). Figure 7-II illustrated the SEM image of the resin/dentin interface of the specimen that belonged to the oblique technique. The bonded interface showed a thin hybrid layer with many long with resin tags at the interface with a small continuous gap along the bonded interface. On the other hand, it was observed that when the composite was placed with the horizontal technique, a uniform, thick hybrid layer with numerous short resin tags penetrating inside the dentinal tubules was visible, provided a marginal continuity and good composite adaptation with no gap at the tooth restoration interface (Figure 7-III). The good bond was observed only with the horizontal placement technique. The SEM images of the vertical placement technique showed a non-uniform hybrid layer with short, and thin resin tags extend to a small distance of dentinal tubules with gap formation along with the interface (Figure 7-IV).

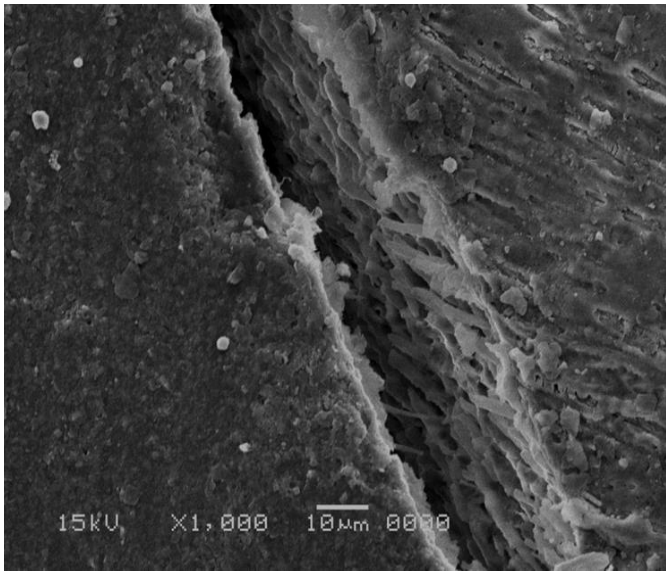

Figure 7-I: SEM photomicrograph of resin/dentin interface of bulk placement group of showing a thin hybrid layer, long and ruptured dentin resin tags arranged perpendicular to the interface with continues gap along interface.

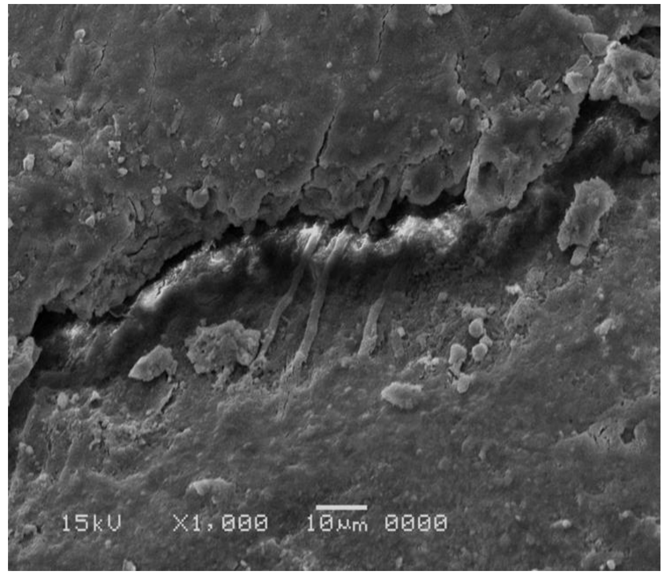

Figure7-II: SEM photomicrograph of resin/dentin interface of oblique technique showing a thin hybrid layer with many long resin tags with small continues gap along interface.

Figure 7-III: SEM photomicrograph of resin/dentin interface of horizontal placement technique showing hybrid layer with numerous short resin tags penetrating inside the dentinal tubules.

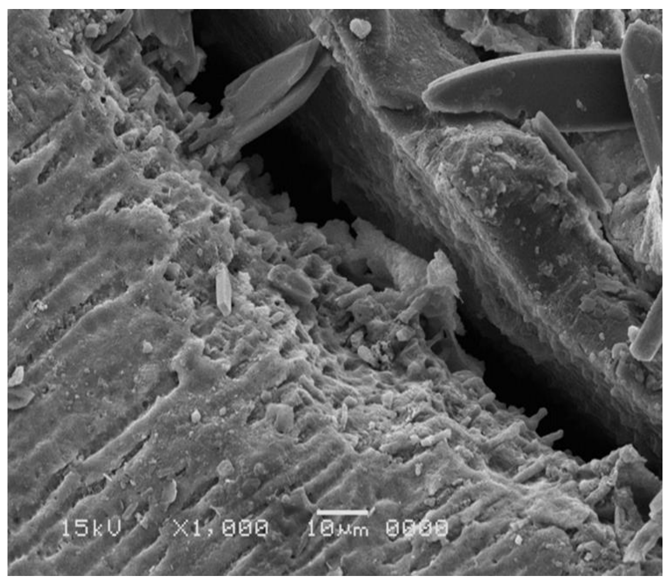

Figure 7-IV: SEM photomicrograph of resin/dentin interface of vertical placement, shows a non-uniform hybrid layer, with short, thin resin tags extend in to small distance of dentinal tubules with gap formation along the interface.

Figure 7I-7IV: SEM photomicrograph of resin/dentin interface of specimen's using four different placement techniques.

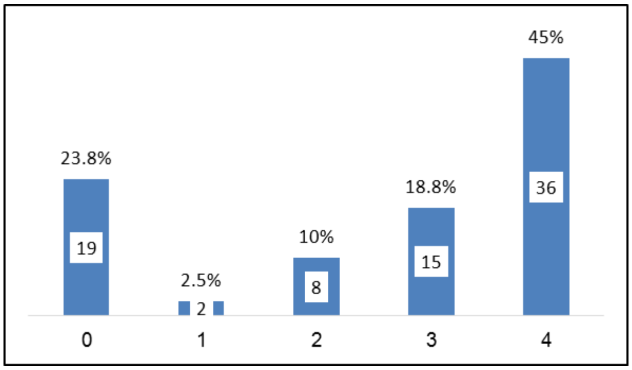

Figure 1: Microleakage scores (0-4) and numbers of composite restorations among the study specimens

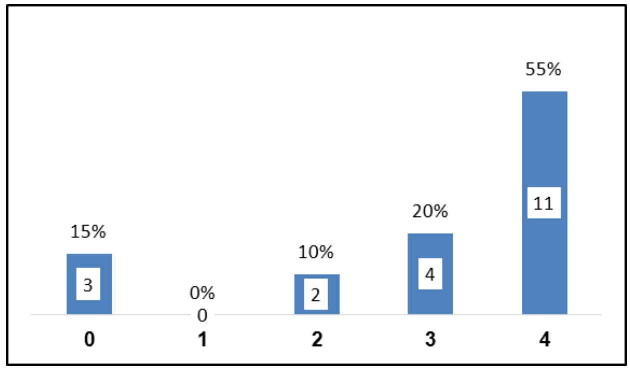

Figure 2: Microleakage scores (0-4) of composite restorations using a bulk technique (n=20)

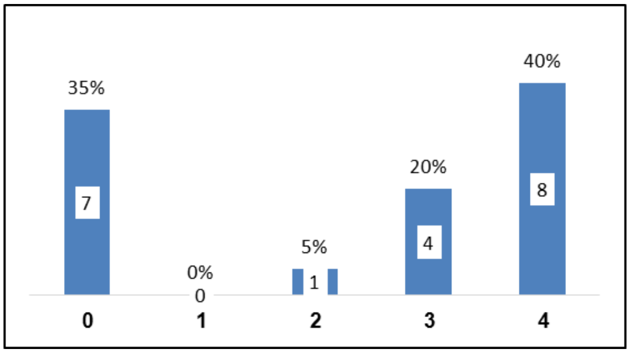

Figure 3: Microleakage scores (0-4) of composite restorations using horizontal layering technique

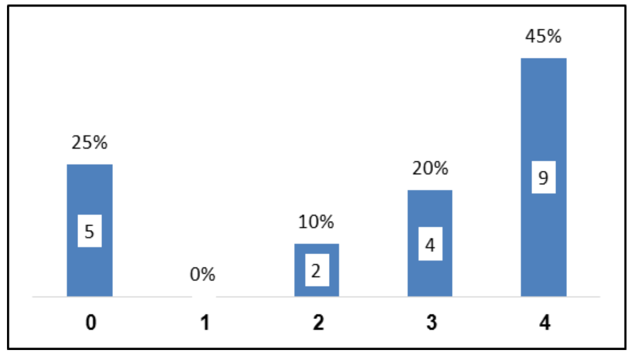

Figure 4: Microleakage score (0-4) of composite restorations using oblique layering technique

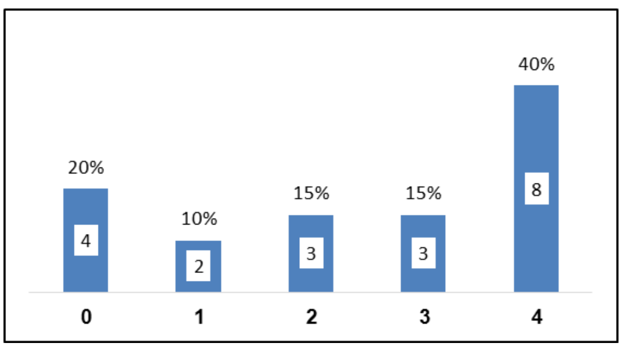

Figure 5: Microleakage scores (0-4) of composite restorations using vertical layering technique

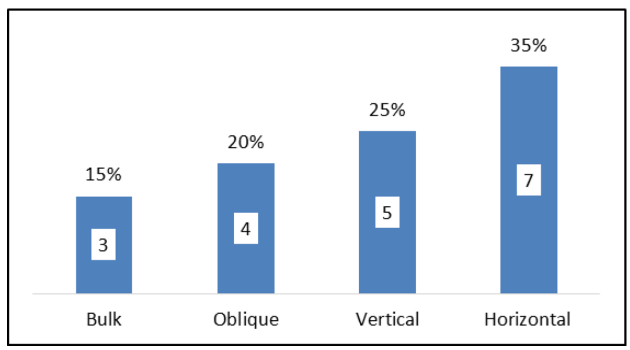

Figure 6: Distribution of no microleakage, score zero in bulk-fill composite restorations in different techniques (n=80) using Fisher exact test for

Figures1-6: Microleakage scores of composite restorations using different placement techniques.

DISCUSSION:

This in vitro study was performed to assess the microleakage of class II cavity restored with bulk-fill composite resin material packed in the cavity preparations using four placement techniques. The outcomes of the study showed that microleakage is quite common in different types of composite placement techniques. These findings could be attributed to the polymerization shrinkage which is considered an inherent property responsible for the main shortcoming of composite resin material.[28] In addition, polymerization shrinkage increases in a cavity with high a C-factor as in the case of class II cavities. These results could be also related to the restorative procedures and curing protocol.[29] Literature reported that the differences in the volumetric changes between the resin and the tooth structure during temperature changes induced microleakage and gap formation.[30]

Moreover, the manufacturer claimed that Tetric N-Ceram bulk-fill composite has a high viscosity, with a nanofiller content of 79-81% wt. producing a volumetric shrinkage of 1.74% and shrinkage stress of 1.1 MPa.[31] Others added that the viscosity of the bulk-fill restorative material influenced the proportion of gap-free marginal interface and the internal adaptation in dentin.[32]

The obtainable results of the distribution of microleakage scores within each group denoted that, the highest percentage of specimens belonged to score 4, while the lowest one was recorded for score 2 among the entire testing groups. The absence of score 1 in some groups could be ascribed to the fracture of the undermined enamel at the unbeveled gingival margin during specimens preparation and sectioning. Or it could be due to the propagation of minute cracks in dental enamel during thermocycling owing to repeated hot and cold cycles which allow dye penetration to dentin.[33]

Statistical analysis (Table 2) revealed that there were no statistically significant differences in microleakage scores between the different placement techniques (P=0.610), although incremental placement techniques showed less microleakage than bulk placement technique. The explanation for these results could be attributed to the fact that when composite was placed inside the cavity in a single increment, the material contacted four walls at a time leaving only two free unbounded surfaces. In such a case, the C-factor is high,[34] and therefore possibility of gap formation and adhesive bond failure.[35] Another possible explanation could be related to ineffective or inadequate curing at the deeper layer of the composite restoration.[36] Our findings were in line with previous studies that demonstrated that the placement of a large increment of bulk-fill resin composite into a cavity increased the potential of creating high shrinkage stress and induced more strain.[35, 37] This is because the buccal and lingual walls are pulled together which might cause adhesive failure and enhanced microleakage.[35, 37]

Our results coincided with Özel and Syman, 2009,[38] Giachetti et al., 2006,[14] who suggested that using layering or increment techniques in Class II cavities reduces the adverse effects of polymerization shrinkage and marginal gap formation comparing to the bulk technique. The authors reported that their results were attributed to the use of a small volume of material with the incremental technique which reduces the ratio of bonded to unbonded surfaces, thus decreases the C-factor and stresses on the composite restoration. Thus provides minimal contact with the opposing cavity walls during polymerization.[14, 38] On the contrary other investigators found no significant difference between bulk and incremental techniques when evaluating microleakage of class II composite restorations.[39] Cecelia and Aranha in 2004 added that Tetric Ceram composite placed in bulk technique did not differ from the incremental technique, and had significantly less microleakage than Surefil composite either in bulk or in increment techniques.[40]

The horizontal placement technique (Gp II) of the bulk-fill composite showed the least microleakage among all testing groups (Figures 3). According to Welime, 2014 the horizontal placement technique was ranked as the easiest to use clinically amongst the incremental placement techniques.[41] Other researchers added that this technique is an acceptable method for resin composite insertion at enamel margins since standardized layers of equivalent volume allow superior control of the polymerization shrinkage levels.[35] In the same context, others added that the location of the gingival wall at enamel margins improves bonding since enamel is a better substrate for bonding especially with a selective total-etch adhesive system that creates microporosities, allowing penetration of the adhesive, thus forming a micromechanical bonding with the resin composite restoration.[42]

Our findings were in agreement with Frankenberg et al., 2007 who found that the horizontal layering technique had the best marginal and bond qualities compared to the vertical and oblique layering techniques.[17] Yumei et al, 2009 reported that the shrinkage of a single horizontal thin layer of composite generates remarkably less tensile force than the contraction of a bulk of composite that fills the whole cavity.[43]

Perhaps the most important contribution of horizontal incremental technique would be an adequate polymerization for bulk-fill composites and an adequate degree of conversion of the material in this thickness, as it was postulated by Campas et al., 2014 in their study.[44] In this regard, the result could be related to the benefits claimed by the manufacturer that higher translucency and light transmission properties of bulk-fill resin were enhanced, and modified by adding prepolymer shrinkage stress relievers, polymerization modulators chemically embedded in the center of polymerizable resin backbone, high-molecular-weight base monomer to optimize flexibility and network structure and highly light-reactive photoinitiator system, benzoyl germanium (Ivocerin) to enable rapid polymerization and greater curing depth.[44] On contrary to our result, several authors reported that using this technique for composite application leads to an increase in the C-factor, and thereupon increases the shrinkage stresses between the opposing cavity walls which lead to microleakage.[45, 46]

The next best result of microleakage distribution was the oblique technique (GpIII) (Figure 4). Our results were in agreement with Lopes et al.,[47] and Loguercio et al,[48] who documented that the combined simultaneous different layers using the oblique placement technique may result in much more shrinkage stress and microleakage. In addition, Sillas and Jose, found that the oblique technique exhibited significant microleakage despite the reduction in C-factor, when investigated the marginal adaptation of class II adhesive restorations.[49] The vertical placement technique in the current study produced the highest microleakage proportion among the increment placement techniques. It has been reported that; to eliminate microleakage and a gap formation at the gingival wall in a restoration packed with vertical technique, the curing process should be started from outside or behind the corresponding wall in which the increment is packed.[50]

The results of the current study revealed that there were no statistically significant differences in the overall mesial and distal restorations. It is believed that the location of the preparation on either mesial or distal aspects of the tooth should not significantly affect the results because all cavities on both sides were prepared similarly and restored with the same type of composite resin. This result may reflect the standardization which was followed in each step during specimens' preparation and testing.

A scanning electron microscope (SEM) was chosen to be used for marginal adaptation analysis in the present study. The quality of the marginal seal at the gingival margins of restorations was evaluated according to Sabatini et al., 2010 who categorized the gap criteria into two categories; [51] 1. No gap: This means the margin appears with smooth and uninterrupted tooth-restoration continuity. 2. Presence of gap: means a distinct gap exists at the tooth restoration margin. Assessment of the SEM images of the selected specimens showed that only the horizontal layering technique of the bulk-fill composite demonstrated good quality hybrid layer with a marginal continuity and good adaptation with no gap at the tooth restoration interphase. This result could be possibly contributed to the adequate polymerization and the sufficient degree of conversion of the bulk-fill composite increments (Figure 7-III). Evaluation of the SEM images of the other placement techniques revealed that there is inadequate bonding to tooth structures probably due to contraction forces resulting from polymerization shrinkage that might give rise to gap formation at cavity wall and restorative material interface. layer

Marginal integrity of resin composite restoration might be affected by various factors including the cavity size, the angle at which enamel prisms and dentinal tubules are cut based on their location, the procedure in which dental hard tissues are conditioned, the layering protocol, and the polymerization technique used.[52] Therefore in the present study it appears that differences in the placement techniques were responsible for differences in gap formations.[53]

CONCLUSIONS:

Within the limitations of this in vitro study and based on the results, it can be concluded that: microleakage could not be eliminated by any of the tested placement techniques despite the significant advances in composite materials and dentin bonding systems. Incremental placement techniques showed a lower score of microleakage compared with the bulk placement technique. The horizontal layering of bulk-fill composite showed the best results in terms of the marginal seal with tooth structure.

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