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Cuspal Deflection and Marginal Gap of Class II MOD Using Preheating Bulk-Fill Composite with Different Application Techniques

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Abstract

The novel bulk-fill composite to reduces time consumption and overcomes sensitive incremental techniques. Cuspal deflection and marginal gap are the common problems of composite material restoration. This in vitro study was conducted to evaluate the cuspal deflection and marginal gap of CL II MOD cavity restored with preheated One bulk-fill composite resin applied with different application techniques. Methodology: 48 upper 1st premolar teeth were prepared as CL II MOD cavities to be restored with One bulk-fill restorative composite resin without (Group A) or with preheating (Group B). Each group (n=24) was subdivided into three subgroups (n=8): A1 and B1 were restored in one increment, A2 and B2 were restored using two increments, and A3 and B3 were filled using a sublayer of a flowable composite resin. The intercuspal distance of the buccal and palatal cusps was recorded before preparation, after 5 minutes, and 24 hours from the restoration. The cuspal deflection (CD) was calculated by subtracting intercuspal distance after restoration (5 minutes or 24 hours) from before preparation for all subgroups. The marginal gaps were recorded from images by scanning electron microscopy (SEM) for both the proximal and gingival margins. The mean values of the data were analyzed statistically using one-way ANOVA and paired t-test at $p < 0.05$. Preheating of One bulk-fill resin did not produce a significant effect on cuspal deflection compared with the control ($p > 0.05$) however, the incremental layering of One bulk-fill composite recorded significantly lower cuspal deflection with or without preheating. While preheating of bulk-fill produced a significant decrease of both marginal gaps compared with the control subgroups ($p \leq 0.05$). Preheating One bulk-fill composite before curing did not influence the cuspal deflection while improved marginal adaptation in different application techniques. The incremental technique significantly reduced cuspal deflection and marginal gap.

Introduction:

The novel bulk-fill composite resin was introduced to be used for a single bulk insertion to overcome the time-consuming and sensitive technique problems of the incremental technique used with conventional composite resin. Recent studies reported that the bulk-fill composite material produced less polymerization shrinkage stresses than conventional materials (1). Bulk fill composite, particularly the highly viscous type with high filler content, faces a problem in adaptation in the cavity. Therefore, several ways were suggested to increase flowability and reduce film thickness, such as preheating before curing, which was used for its ease and simplicity (2,3). This popular method has been studied by many researchers regarding its effect on mechanical, physical, and clinical performance (3,4). However, Abdul Majeed et al. (2020) (5) stated that the effects of preheating on composite properties and clinical performance are not fully confirmed and still need to be investigated. From a clinical point of view, the accurate method to evaluate the polymerization shrinkage stresses effect is by measuring the cuspal deflection of the tooth after restoration (6). The cuspal deflection is defined as the deformation of cavity walls of teeth. Such a deflection can arise from several factors, such as the size or shape of the remaining tooth structure; and the amount and nature of polymerization shrinkage stresses (7). The cuspal deflection may cause enamel cracks and fractures, occlusal disturbances, and post-operative sensitivity (8,9). Several studies interpreted that different bulk-fill materials have lower cuspal deflection than conventional materials (10,11). Others stated that there were no significant differences between bulk fill material when bulk insertion and conventional materials used in incremental technique (12,13). Another most common problem associated with composite material is the poor adaptation and marginal gap formation leading to microleakage, postoperative sensitivity, and secondary caries. Although the high filler content

bulk-fill composite decreases polymerization shrinkage and enhances physicomechanical properties of the composite, it makes it difficult to adapt. Darabi et al. (2020) (14) stated that the preheated bulk-fill composite decreased the marginal gap width. In contrast, Mohanapriya et al. (2020) (15) showed that preheated bulk fill has poor internal marginal adaptation with increased frequency of gap formation. Hence, there was little evidence and no consensus on the effect of preheating of bulk-fill composite resin on the cuspal deflection and marginal gap in MOD Class II cavities; therefore, this study was conducted to evaluate the effect of preheating of One bulk-fill restorative composite in different application techniques. The null hypotheses of this study were that there is no difference in cuspal deflection and the marginal gap with or without preheating of bulk-fill composite, and there was no effect of different application techniques of bulk-fill composite resin on cuspal deflections and marginal gaps.

Materials and Method:**Teeth selection and mounting**

Forty-eight intact human maxillary first premolars were collected within two months for this study. The teeth were extracted for orthodontic treatment from patients with an age range from 18-33 years. The inclusion criteria for the selected teeth were free from caries, malformation defects, cracks, attrition, previous filling, or defects resulting from extraction. The examination was performed using a digital microscope (DM09 7. LCD 1200. Tomlov, Shenzhen, China) (14). The maximum variation allowed for bucco-palatal width, mesiodistal, and occlusogingival length was 5 % for standardization of the dimensions (10,16).

The teeth were cleaned then disinfected with thymol 0.1% and stored in distilled water at room temperature. Then, the teeth were fixed using a dental surveyor (Paraline, Dentaureum, Germany) inside a fabricated silicon mold of 25 mm³ dimensions with a central hole of 12mm in

diameter with self-cure acrylic material (Shanghai new century dental materials, Shanghai, China). The teeth were inserted up to 2mm cervical to the cemento-enamel junction.

Reference point placement

Two reference points on the tip of the buccal and palatal cusps were placed to be used to measure the intercuspal distance by making an indentation with a diamond round bur (1/4 diameter) (Mani-INC, TOCHIGI, Japan) in a high-speed handpiece with water coolant. To standardize the depth of the indentations, the whole bur diameter was entered. The teeth were evaluated under a microscope to assure the absence of cracks produced during the preparation of indentations and that any tooth with a crack was neglected (17). These indentations were filled with colored nail polish by injecting a disposable syringe to appear as circles under a stereomicroscope. After that, clear polyvinyl siloxane impression material (Chemi-sil clear, B&E, Korea) was used to take the impression of the occlusal surface (stamp technique) to return the tooth anatomy with minimum finishing and polishing (18).

Cavity preparation

Using a parallel-sided, flat-ended diamond fissure bur (Mani-INC, TOCHIGI, Japan) in a high-speed handpiece (NSK, Japan) with water cooling, a class II MOD cavity with parallel walls was produced in each tooth. To prepare the cavity, a super color permanent marker was used to create a boundary of the cavity (7). The preparation was performed with the use of a modified dental surveyor for standardizing the cavity preparation. The surveyor's plate was placed on a horizontal plane, and the tooth was fixed on the surveyor's table. Then, using a high-speed handpiece (NSK, Japan) was fitted to the surveyor's modified arm. the cavity was prepared with mesial and distal movements to produce a mesio-occluso-distal (MOD) cavity (10). The cavities were prepared in each premolar with a buccolingual width of 3 mm, and a cavity depth of 3 mm

measured from the palatal cavosurface to the pulpal floor. The mesial and distal boxes were prepared with 1mm depth and 1mm mesiodistal width Fig. (1). Cavo surface margins were at 90 degrees, and all the internal angles were rounded (11).

For standardization, the dimensions of the diamond bur used were 4mm bladed of 1mm diameter (Iso109/010 FG) and marked by an indelible marker to 3mm for standardizing the depth to the pulpal floor. Each bur was used to prepare 4 teeth and then was discarded. The cavity width was measured using a digital micrometer, and the depth was detected using a periodontal probe from the tip of the cusp to the gingival seat. All margins of the cavity were in enamel (14).

Teeth grouping

The prepared teeth were divided randomly into two main groups: A and B (n=24). Then, each group was subdivided into three subgroups (n=8) according to the restorative technique: A1 and B1 were restored in a single layer, A2 and B2 were restored in two layers, and A3 and B3 were restored with a sublayer with a flowable resin Fig. (2).

Adhesive protocol and matrix placement

After cavity preparation, teeth were subjected to an adhesive procedure: acid etching (enamel and dentine etching for 30 s and 15 s, respectively) using 37% phosphoric acid (Super etch, SDI, Australia), rinsing and drying for 5 s with an absorbent. After that, a drop of Adper 3M adhesive system (Adper adhesive system, 3M ESPE Filtek, St. Paul, MN USA) was applied, and gentle air thinned the bond layer, then photopolymerized for 10 seconds by light cure (radii plus, SDI, Australia) with an intensity of 2100 mW/cm² that was checked by a radiometer (SDI, Australia) for each restoration (6,16).

Before the application of the composite resin, a Tofflemire matrix was used applied around the tooth, with the upper end reaching the area of the marginal ridges of both sides to enclose the MOD

cavity (14) and to prevent interference with the silicone stamp.

Restoration techniques

The composite material used in this study was One bulk-fill restorative material (3M ESPE Filtek, St. Paul, MN USA). For Group A, the resin was used at room temperature (23°C) while for Group B, the resin was pre-heated by a warmer (SJ-JRQ, Sheng jean, Foshan, China) before application into the cavities (14). The composite materials were applied immediately after removing them from the heating device and cured after 15 seconds (19). The restoration technique was applied as follows:

Subgroups A1 and B1 restored with a single bulk increment of the One bulk-fill resin that was applied within the tooth cavity. Then, the stamp impression was pressed gently to return the occlusal anatomy. Then, the restoration was cured occlusally for 20 seconds by The LED curing unit and by touching the tips of the buccal and palatal cusps of the tooth to achieve maximum curing depth and to maintain a fixed distance for standardization. After removing the matrix band, another 20 seconds of curing from each of the buccal and palatal sides was performed by touching the walls externally to ensure curing of the composite resin at the gingival margins of the proximal boxes. For subgroups A2 and B2, the bulk fill resin was used in two horizontal increments (each increment of 2 mm thick cured for 20 seconds). The first layer was applied and cured, then the second increment was added and completed as with subgroups A1 and B1.

For subgroups A3 and B3, a sublayer of a flowable base (Supreme flowable restoration, 3M ESPE Filtek, St. Paul, MN USA) of a 1mm thickness was applied on the gingival seat and cured for 20 seconds (20). Then, One bulk-fill resin was placed in one increment on it and completed as with subgroups A1 and B1.

Cuspal deflection measurement

For measuring the intercuspal distance (ICD) between the two reference points on

the buccal and palatal cusps, a micrometer of Image J software after saving the pictures taken by microscopy Stereomicroscope (A. KRUSS Optronic, Kruss, Hamburg, Germany) 75X magnification with a camera (AMSCOP) (10). ICD was measured before cavity preparation (IC1) which was used as a baseline, IC2 was measured after 5 minutes, and IC3 after 24 hours of restoration. The cuspal deflection CD1 and CD2 were then measured as follows:

$$CD1 = IC2 - IC1 \text{ and } CD2 = IC3 - IC1.$$

Marginal gap measurement

Images for the restorations were taken using a Scanning electron microscope machine (AxiaChemiSEM-Thermo Scientific. USA). These images were used to measure the proximal and gingival marginal gaps width for all the samples. After drying and gold spattering, six samples (one sample from each subgroup) were placed together each time at the chamber with a pressure of 12 pa, at a low vacuum and a high voltage. The maximum marginal gaps of the proximal and gingival margins were measured in a micrometer with a software program (Microscope user interface, V27.1.1.12226, 2021) at X 5000 magnification Fig. (3) and Fig. (4). The proximal and gingival gaps were calculated using the width of the marginal gap between the restoration and tooth margins. The three largest widths were collected from the proximal and gingival margins and used their mean to represent the proximal and gingival margin gaps, respectively.

Statistical analysis

Data were analyzed using (SPSS Statistics 22, IBM. USA). A paired t-test was also used to analyze the difference between the mean values of cuspal deflection after 5 minutes and 24 hours from the restoration. One-way (ANOVA) test and post hoc Tukey's test were used to assess any differences among the subgroups for the mean values of cuspal deflections and marginal gaps at the gingival and proximal regions. All the tests were carried out at a level of significance of 95%.

Results:

1- Cuspal deflection result

The mean values and standard deviation of the cuspal deflection values after 5 minutes (CD1) and after 24 hours from restoration (CD2) were summarized in Table (1). One-way ANOVA showed a significant difference at both times. Tukey's test showed that the cuspal deflection of both subgroups A2 (incremental, no heating) and B2 (incremental, preheating) were significantly less than all other subgroups after 5 and 24 hours. There was no significant difference between all subgroups of group B(preheating) compared with their control subgroups of group A (non-heating) after 5 minutes and 24 hours.

Paired t-test showed a significant difference between cuspal deflection after 5 minutes (CD1) and after 24 hours (CD2) from restoration for all subgroups ($p \leq 0.05$).

2- Marginal gap results

The mean values and standard deviation of the maximum marginal gap values of gingival and proximal sides (in micrometer) are summarized in Table (2). One-way ANOVA showed significant differences among the subgroups ($p \leq 0.05$). Comparing the subgroups of each group \leq individually, Tukey's test showed significant differences in the gingival gaps as well as at the proximal gaps ($p \leq 0.05$). For the subgroups of a group, A (non-heated), A1(bulk), A2 (incremental) and A3 (flowable liner + bulk) were all significantly different from each other. This was also true for the subgroups of Group B (preheated), except no significant difference was recorded between subgroups B2 and B3 ($p > 0.05$). On the other hand, comparing preheated subgroups with their control non-heated ones, the results showed a significant difference between B1 and A1, and between B2 and A2, however, no significant difference was recorded between B3 and A3. For the values of the proximal gaps, the results showed a statistically significant difference between

the subgroups of both groups except between A2 and A3, and between B2 and B3 the difference was not significant. Besides, significant differences were recorded between all the three pre-heated subgroups compared with their respective non-heated subgroups.

Discussion:

Preheating composite resin before curing is one of the methods that was suggested to reduce film thickness and viscosity of the resin (2). Many studies approved that preheating has improved mechanical and physical properties (3,4). Other researchers have failed to assess any negative effect in preheating composite resin before light curing (21,22). However, the effect of preheating on the mechanical properties and clinical performance of bulk-fill composite resin still needs to be investigated (5).

Cuspal deflection

The cuspal deflection of restored teeth is one of the clinical implications of polymerization shrinkage stresses produced by the composite resin restorations (6,23). Numerous factors can affect the cuspal deflection of a tooth, such as the type of tooth, cavity design and amount of remaining tooth structure (6,24), curing mode (25), and the type of resin composite material (6,10). The current study showed an inward cuspal deflection for all subgroups. Previous studies also reported inward cuspal flexure after restorations and related that to polymerization shrinkage stresses of organic monomer within composite resin materials (10,11).

The results of this study recorded no significant difference between the preheating and non-heating subgroups. This result confirms that the preheating technique before curing did not affect the polymerization shrinkage stresses and that the degree of monomer conversion was not affected by preheating of the resin (22,26). Abdulmajeed et al. in 2020 (5) showed that the young's modulus of One bulk-fill restorative composite could be decreased significantly in preheating

technique. The reduction in the elastic modulus was reported to decrease the polymerization forces (27). However, in the current study, curing of the heated composite resin was performed after 15 seconds of application within the cavity. This time period could cause relief of thermal contraction stresses (28), which can be added to polymerization shrinkage stresses if the polymerization is to be conducted immediately (29). Lempel et al., in 2019 (30), on the other hand, recorded an increase in the degree of conversion by the preheating technique and subsequently an increase in the polymerization stresses. This difference in the results could be related to the use of a conventional composite type in the later study.

The results of this study showed significant differences between the different application techniques for both non-heating and preheating groups. A significant decreased CD was recorded for the incremental technique compared with the other two subgroups. These differences were attributed to a decrease in the polymerization shrinkage stresses by decreasing the amount and thickness of composite resin layers. These results corresponded with the results of Pottier et al. (2020) (31). Santis et al. in 2020 (6) also reported that the cuspal deflection of the bulk-fill technique was larger than the incremental, but with no statically significant differences between the two techniques using a Sonic bulk-fill composite resin. The results of this study recorded no significant effect of the flowable sublayer when compared with those without it. It has been reported that a flowable composite contains a large percentage of organic monomers, which can increase the polymerization shrinkage and stresses (32). On the other hand, other researchers stated that the flowable composite liner can decrease cuspal deflection (29, 33). This decreased cuspal deflection was credited to a low elastic modulus of the flowable composite material, which absorbs the stresses and decreases the wall deflection (27). However, the amount of flowable composite used in the present study was

thin just at the gingival seat of the boxes (1mm depth and width) compared to previous studies; therefore, no effect on polymerization shrinkage stresses and cuspal deflection of the walls of the MOD cavities were recorded. Paired t-test results showed a significant reduction in the cuspal deflection after 24 hours compared with 5 minutes from water storage of composite resin for both groups. This result is in line with Behery et al., in 2016 (16) and Elsharkasi et al., in 2018 (10). Such a result can be related to the nature of polymer within resin composite, which was considered a viscoelastic material characterized by stress relaxation behavior (34). Another factor that can affect the reduction of intercuspal distance after the storage is the water sorption of resin polymers which leads to hygroscopic expansion. This expansion depends on the quality and stability of the silane coupling agent between fillers and polymers. The hygroscopic expansion is a slow and gradual process and can compensate for the stress of polymerization shrinkage (35). The organic contents of One bulk-fill composite resin are composed mainly of hydrophobic monomers: UDMA and AUDMA with other monomers such as TEGDMA (less than 1%). Bociong et al., in 2017 (36) showed that the more hydrophobic monomer (high molecular weight) such as UDMA leads to less water sorption and less stress relaxation than TEGDMA (less hydrophobic, low molecular weight). Therefore, the gradual increase in the intercuspal distances after water storage when using One bulk-fill composite resin could be related to the high percentage of hydrophobic monomers within it. Other factors that play a role in the relaxation of the cuspal deflection are the elasticity of the tooth and the possible formation of a marginal gap (10). This result was also true for preheating technique subgroups. It was reported that the relaxation and hygroscopic expansion of resin composite may not be affected by preheating of it (29).

Marginal gap

For the marginal gaps, the results showed that preheating of One bulk-fill resin significantly decreased both the gingival

and proximal marginal gaps in all application techniques (except when used with a sublayer at the gingival margins) compared to the non-heating control group. These results corresponded with a previous study by Darabi et al., in 2020 (14). It has been reported that marginal gaps improvement can be related to the fact that preheated bulk-fill composite resin can reduce its flowability, reduce the surface tension ability, and improve its handling behavior and adaptation (37). Composite material has a viscoelastic behavior (38), so the reduction in viscosity by preheating was due to the disturbing of the thermal energy of the hydrogen bonding interactions between filler and matrix. The monomer molecules became freer to movement leading to increased flowability (39). Abdulmajeed et al., 2020 (5) also reported a decrease in the young's modulus of preheated One bulk-fill composite after polymerization. It has been reported that the young's modulus of a composite material highly affects the marginal gap of the final restoration (40). Decreasing the modulus of elasticity, decreased the polymerization forces, and enhanced the interfacial layer between the tooth and the restoration.

The present study results of the preheating composite were in line with the studies that speculated the polymerization shrinkage was not affected by the heating of composite above 60°C before curing. The polymerization shrinkage of bulk fill composite is not altered by the preheating even when the degree of conversion was increased (41). However, this result does not coincide with the results of Mohanapriya et al. in 2020 (15) interpreted that preheating technique increased the marginal gap of the bulk-fill composite. This difference can be related to the that the cavity design of that study was terminated in dentin gingivally, while in the current study all the margins were in enamel. When comparing between the different techniques, the results showed that the bulk fill technique recorded significantly higher gingival and proximal gaps than the other two techniques. The increase in width of the marginal gap in the bulk-fill technique subgroups than the

incremental ones can be attributed to two reasons. First, polymerization shrinkage and polymerization stresses were increased by increasing the thickness of a composite resin inserted by increasing the C-factor. This result is in association with the results recorded by De Oliveira Correia et al., 2018 (43) Tsujimoto et al., 2020 (44) stated that it would be safer to use the incremental technique because a high number of bulk fill composite types showed a significant increase in the polymerization stresses when used in the bulk technique. The second reason is the lack of the initial adaptation in bulk fill placement, especially in the cavity's angle areas (45) due to the highly packable nature of the One bulk-fill composite (5). The results of this study also showed that using a flowable layer+ bulk-fill produced a significant decrease in the gingival marginal gaps compared with both single bulk and incremental techniques. The flowable composite with considerably low viscosity can produce well marginal adaptation at the gingival margin by superior wetting of the cavity. Although the flowable composite has a high amount of resin which was responsible for increasing polymerization shrinkage, it acts as a stress reliever due to reduced filler content (46). In this subgroup, the 1mm thin layer of a flowable resin at the gingival margin could affect the total magnitude of the shrinkage vectors. Kaisarly et al., in 2021 (47) stated that the application of a thin flowable liner that is covered with other layers or layers of bulk-fill composite resin can influence the magnitude of the shrinkage vectors. The smaller shrinkage vectors in the covering increment(s) were influenced by the shrinkage vectors of the previously cured increment. Feiz et al., (2021) (20) reported that the flowable composite liner should be used in the gingival margin of class II to reduce microleakage as it is closely related to viscosity and polymerization shrinkage of composite resin. Besides, Sampaio et al., (2020) (48) using Micro-CT, recorded that the flowable liner caused the spreading of excess restoration on the marginal region, thus decreasing the cervical marginal gap percentage. However, Sampaio and co-workers used a

flowable liner without curing and then placed increment of composite resin above the liner and cured together, so this technique needs some pressure, which may increase the probability of spreading the material over the margin. On contrary, it has been concluded that a flowable composite is composed of a high percentage of monomer, which can increase the polymerization shrinkage and stresses (32) and the polymerization stresses were the main factor of the marginal gap (49,50). A previous in vivo study by Lindberg et al., 2005 (51) showed that a 2mm thickness flowable composite when used as a liner could not improve the marginal gap. The inconsistency in results with the current study could be related to the difference in the volume of a flowable liner which was larger than in the current study as the polymerization shrinkage amount increased. By focusing on the proximal margin gaps of subgroup A3, the results were also significantly decreased when compared with the single bulk layer subgroup however it was not significant with the incremental technique. The thin flowable layer affected the external marginal gap of the material placed above it. The volumetric polymerization shrinkage decreased, leading to a decrease in polymerization stresses and C-factor that can affect the marginal gap (52,53). In addition to that Kaisarly and others, in 2021 (47) revealed that the application of flowable liner in any thickness can reduce the magnitude of the polymerization vector and improve the restoration adaptation in contrast to the bulk-fill technique with the higher polymerization vector as concentrated unfavorably.

Hence, it is recommended to use a thin or thick layer of the flowable layer underneath bulk-fill composite resin, preferably incrementally.

According to the results of this study, both null hypotheses were rejected. However, further in vivo studies are still needed since in vitro studies cannot mimic the clinical situation and compare different types of bulk-fill composite.

Conclusion:

- 1.** The preheating of One bulk-fill restorative composite did not affect the cuspal deflection of class II MOD cavities while it improved the marginal gap in different application techniques.
- 2.** The incremental layering technique One bulk-fill restorative composite significantly decreased the cuspal deflection and the marginal gap compared with one increment application of the bulk-fill composite with or without preheating.
- 3.** The use of a flowable liner in the gingival seats did not affect the cuspal deflection when used underneath One bulk-fill composite resin while significantly decreasing the gingival marginal gap.

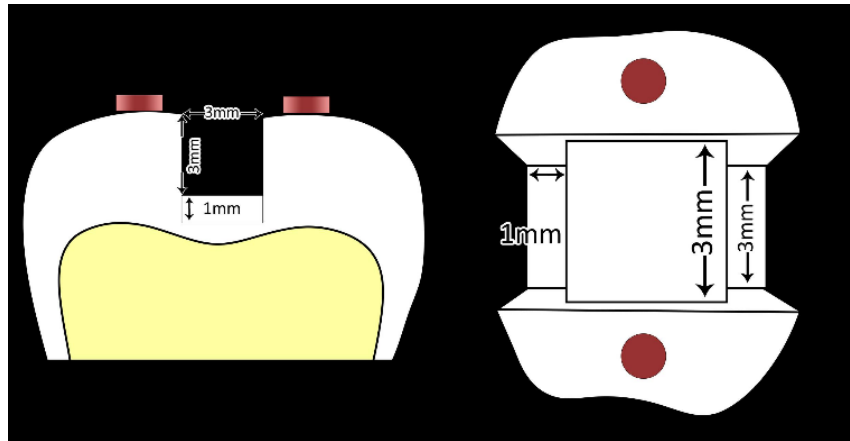


Fig. (1): Dimensions of a prepared cavity

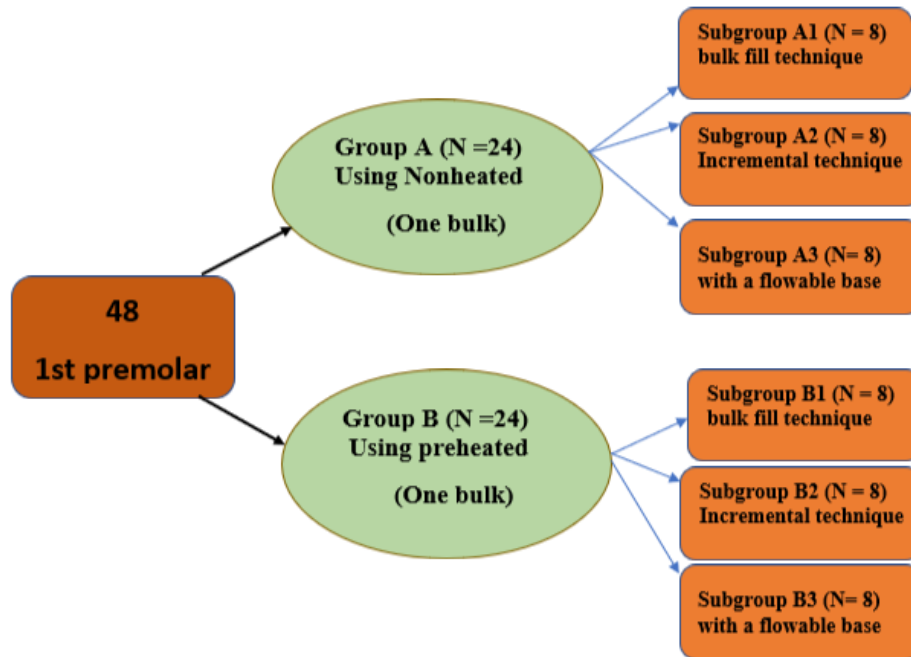


Fig. (2): A diagram showing sample grouping.

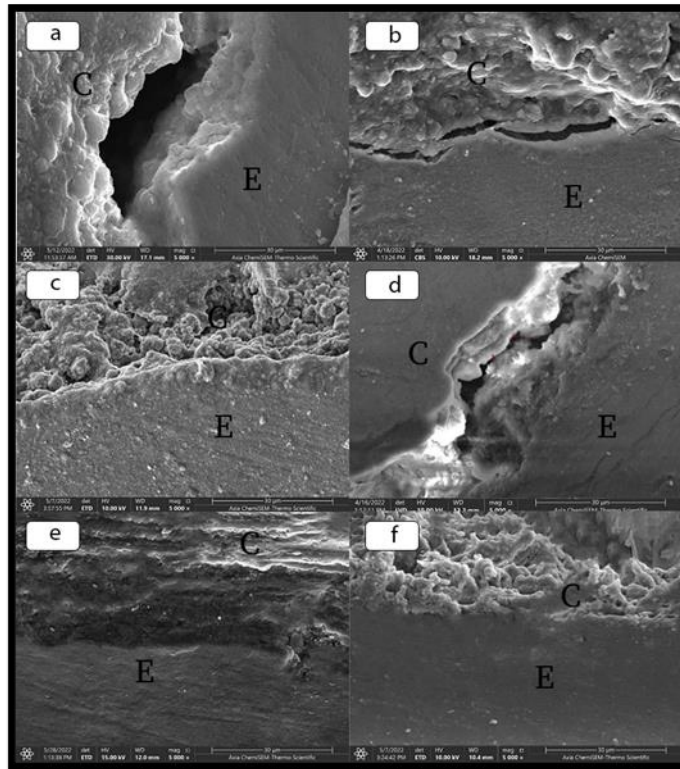


Fig. (3): SEM images at X5000 for the gingival marginal gaps of subgroups A1(a), A2 (b), A3(c), B1 (d), B2 (e), and B3 (f). E=Enamel, C= composite.

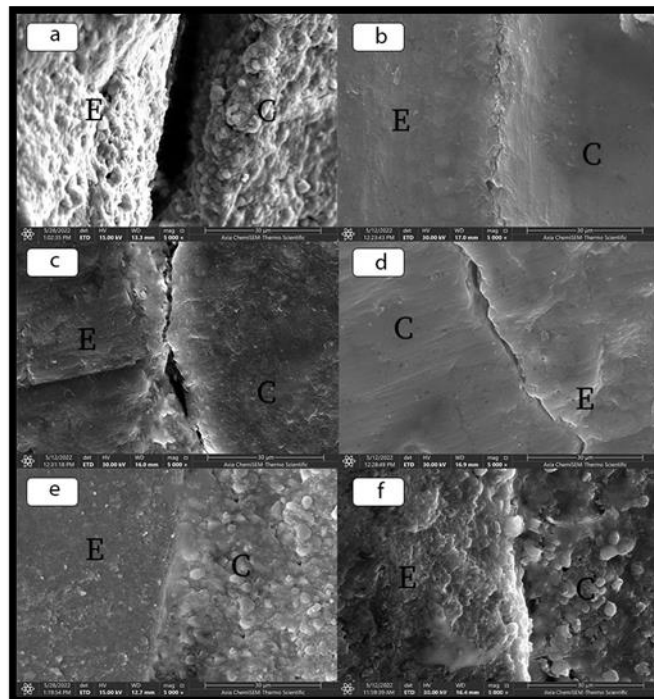


Fig. (4): SEM images at X5000 for the proximal marginal gaps of subgroups A1(a), A2 (b), A3(c), B1(d), B2 (e), and B3 (f). E=Enamel, C= composite.

Table (1): Mean (SD) in μm of cuspal deflection values after 5 minutes and 24 hours from the restoration for all subgroups.

| Group | Subgroups | 5 min (CD1) | 24 hrs. (CD2) |
|-------------------------------------|-----------------------------------|----------------------------|----------------------------|
| | | Mean (SD) in μm | Mean (SD) in μm |
| Group A Non-heated resin | A1(single inc.) | 17.3 (2.4) a | 10.0 (1.7) c |
| | A2(2 inc.) | 12.4 (1.8) ab | 8.0 (1.5) cd |
| | A3 (flowable liner + bulk) | 17.9 (2.0) b | 10.5 (1.3) d |
| Group B Preheated resin | B1(single inc.) | 17.0 (1.4) e | 10.2(1.5) g |
| | B2(2 inc.) | 12.0 (2.0) ef | 8.2(1.3) gh |
| | B3(flowable liner+ bulk) | 17.8 (2.1) f | 9.8 (1.8) h |

* Mean values with the same letter are sig. different at $p \leq 0.05$

Table (2) : Mean values (SD) in μm of the gingival and proximal marginal gaps for all subgroups.

| Group | Subgroups | Gingival gap | Proximal gap |
|-------------------------------------|-----------------------------------|----------------------------|----------------------------|
| | | Mean (SD) in μm | Mean (SD) in μm |
| Group A Non-heated resin | A1 (single inc.) | 6.03(0.6) abc | 5.60(0.8) fgh |
| | A2 (2 inc.) | 1.50 (0.4) ade | 1.4(0.4) fi |
| | A3 (flowable liner + bulk) | 0.43 (0.3) bd | 1.72(0.5) gj |
| Group B Preheated resin | B1 (single inc.) | 1.80 (0.6) ck1 | 1.79(0.2) hmn |
| | B2 (2 inc.) | 0.49 (0.3) ek | 0.51(0.3) im |
| | B3(flowable liner+ bulk) | 0.48(0.3) l | 0.59(0.2) jn |

* Mean values with the same letter are sig. different at $p \leq 0.05$

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