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Original Research Article

Marginal Adaptation of Bulk-Fill versus Layered Resin Composite Restorations

Abdullah Assiri[1], Abdulrahman Alomairy[1], Nashaat M. Magdy[2]

[1]Intern, [2]Assistant Professor of Conservative Dental Science,
College of Dentistry, Prince Sattam Bin Abdulaziz University, KSA

Corresponding Author: Nashaat M. Magdy

ABSTRACT

Objectives: This study was conducted to evaluate and compare the marginal adaptation of class II (MOD) bulk-fill Tetric EvoCeram, SonicFill bulk-fill resin composite, and layered Filtek Z250 resin composite restorations.
Materials and Methods: Thirty MOD cavities were prepared in extracted human molar teeth. The cavities were divided into three groups (n=10) according to the restorative material used (Sonic fill, Tetric Evoceram Bulk fill and Filtek Z250). Marginal adaptation was evaluated using scanning electron microscope.
Results: There were no significant differences ($P<0.05$) between the tested bulk fill restorative materials (Sonic Fill and Tetric Evoceram Bulk fill) and the conventional one (Filtek Z250).
Conclusions: Bulk fill restorative materials (Sonic fill& Tetric Evoceram Bulk fill) showed marginal adaptation like that of conventional resin based composite.

Key words: Bulk Fill, Marginal adaptation, Scanning Electron Microscope, Incremental.

INTRODUCTION

There is great interest in the beauty since the earliest civilizations; composite resins have become a part of this quest to enhance the esthetics of the teeth and mouth. It is now one of the most commonly used direct restorative materials for anterior and posterior teeth. But one of the inevitable drawbacks of dental composites is its shrinkage during free radical polymerization, which may be as high as 3% by volume. [1-5]

When shrinkage occurs while the resin composite materials are inside the cavity and bonded to the cavity surfaces, stresses develop transferred to the tooth restoration interface. If the bond strength is smaller than these stresses, de-bonding might occur resulting in postoperative sensitivity, marginal discoloration, marginal gap formation and recurrent caries. [6-8] However if these stresses are smaller than the bond strength no de-bonding occurs, but the restoration will maintain internal stresses that pull the cusps together, decreasing the inter-cuspal distance width causing cuspal deformation which might cause microcraks and/or cusp fracture. [9,10]

Many clinical methods have been proposed to reduce the shrinkage stress, such as the control of the curing light intensity, [11,12] flowable resin liner application, [13] indirect resin restoration, [14] and incremental layering techniques. [15] However, no method has been shown to be totally effective in abating the effects of polymerization shrinkage.

Despite the controversy over the advantages of incremental build-up of composites (through which the material is gradually placed in layers of 2 mm or less) this technique has been broadly recommended in direct resin composite restoration, because it is expected to decrease the C-factor (the ratio of bonded surface to un bonded free surface), allowing a certain amount of flow to partially dissipate the shrinkage stress. [16] However, in addition to these advantages, incremental technique has number of disadvantages such as; entrapment of voids between the increments, bond failure between the increments and the time taken to complete the procedure long time is required to place and polymerize each increment. [17-19]

In order to overcome many of the downsides associated with the incremental approach to place resins, new restorative materials have emerged that are marketed as bulk-fill composites. However, dentists who have become accustomed to the incremental cure philosophy when placing light-cured composites quite rightly question what specifically has changed to make these bulk-fill composites a viable alternative [20]

Bulk-fill resin-based composites are tooth-colored restorative materials with increased polymerization depth, decreased polymerization shrinkage stresses and decreased cuspal deflection rates. They can be applied into the prepared cavities in layers up to 4or 5 mm thick. [21]

According to some researchers these bulk-fill composites offer a number of advantages for restoring preparations such as simplifying the restorative process and saving time. Furthermore, bulk-fill composites eliminate many of the drawbacks that are associated with incremental layering techniques, such as the risk of contamination and voids forming between the increments. [22-24]

The magnitude of contraction stresses is mainly dependent on the visco-elastic properties of the material. These stresses may be transferred to the margins of the restoration, affecting marginal quality.When marginal quality is not adequate enough, problems such as leakage, recurrent caries and pulpal irritation may occur. Even when considering that an absolutely perfect marginal seal is not achievable clinically, a good marginal quality should be the main objective for clinicians. [13]

The aim of the present study was to evaluate the marginal adaptation of two different bulk-fill composite resins in class II cavities. A conventional posterior micro-hybrid composite resin was used as a control. The null hypothesis was that bulk-fill composite resins exhibit the same marginal adaptation as conventional composite resins that have been applied using the incremental technique.

MATERIALS & METHODS

Two high viscosity bulk fill resin-based composite materials (TetricEvoCeram and SonicFill), and one conventional universal composite (FiltekZ250) were investigated in this study (Table1). Each restorative material was used with its proprietary adhesive system. A well controlled light emitting diode (LED) (Blue Phase meter, Ivoclar/Vivadent AG, Schaan, Liechtenstein) curing unit with light intensity of 800mW/cm^2 was used for polymerization.

Thirty freshly extracted human molar teeth free from caries, restorations, cracks or other defects were selected for this study. All selected teeth were cleaned with a hand and ultrasonic scaler (Wood Pecker Medical Instrument. Co. Ltd China) from any soft tissues or hard calculus deposits. The selected teeth were stored in physiologic saline with 0.05% sodium azid (to prevent bacteria or fungus growth in the storage medium) until the experiment time. [25]

The selected teeth were assigned into three equal groups (n=10) according to the restorative materials used. A 3-cm polyvinylchloride tube was filled with acrylic resin (Acrostone, Egypt) material in the dough stage. The selected molar teeth with their roots were embedded at the tube center and parallel to its long axis; to a level of 2 mm below the cement-enamel junction simulate the position of the tooth in the alveolar bone and also to prevent the reinforcement of the crown by the base. Specially designed Jig was used to standardize the correct position and angulation of each tooth inside PVC ring. [25]

Root surfaces were dipped into melted wax to a depth of 2 mm below the C.E.J to produce a 0.2 to 0.3 mm layer nearly equal to the average thickness of the periodontal ligament. Then the molar teeth were mounted in acrylic resin cylinders

Table1: Materials used in this study.

Restorativesystem	Manufacturer	Resin	Filler	Filler size
SonicFill	Kerr Corporation	Bis–GMA, TEGDMA, EBp DMA	Silicon dioxide, Barium glass	Unreported
Optibond soloplus (two-stepetch-and-rinse		HEMA, GPDA, Mono(2-methacryloxyethyl) phthalate, Ethylalcohol, Water.		
Tetric Evo Ceram Bulk Fill (nanohybrid)	IvoclarVivadent	UDMA, Bis-GMA	Barium glass, Ytterbiumtri fluoride, Mixe doxide prepolymer	550nmavarege Range(40 -3000nm)
ExciteF (two-stepetch-and-rinse	IvoclarVivadent	Etchant:73% phosphoric acid with colloidal silica Adhesive: HEMA, DMA, phosphoric acid acrylate, Silicon dioxide, initiator, stabilizer sinan alcohol solution.		
FiltekZ250 (microhybrid)	3MESPE Konstanz, Germany	Bis-GMABis-EMA,TEGDMAUDMA.	Zirconia/silicaparticles	0.01-3.5µm Average:0.6µm
SingleBond(two-stepetch-and rinse)	3MESPE	Bis-GMA, HEMA, DMA, poly alkenoic acid copolymer, initiator, water, ethanol.		

After polymerization of acrylic resin, each tooth was removed from the resin cylinders. By dipping in the root in a hot water bath, wax spacer was removed from the root surface and from the alveolus of the acrylic resin cylinders. Polyether impression material (Imprgum, ESPE, Seefeld, Germany) was delivered into acrylic resin, then the teeth were reinserted into their respective cylinders and the polyether impression material was left to set. Excess polyether impression material was removed with a scalpel blade to provide a flat surface 2 mm below the CEJ of each tooth.

Standardized large slot MOD cavity preparation was prepared using a high speed hand piece fixed in especially designed jig and fixer (designed at Production Engineering and Mechanical Design Department, Faculty of Engineering, Mansoura University, Egypt). The device allowed accurate movement of the hand piece, results in a nearly standardized cavity width (3± 0.3 mm) and depth (4± 0.3mm).

After every five cavity preparations the bur was changed. The cavity depth was 4 mm from the cavity occlusal cavosurface margin to the pulpal floor. The buccal and lingual walls were prepared parallel without occlusal convergence. The slot MOD cavities were prepared without proximal boxes in order to reduce the preparation variation. All the cavosurface margins were prepared without beveling, and all internal line angles were rounded. [5]

A Tofflemire matrix band was contoured and placed around the teeth and held firmly at the proximal aspects of the teeth. (Total etch dentine bonding systems were used among all products to reduce variability in results that might have occurred if some self-etching systems had been used). [26]

A total-etch technique with 37% phosphoric acid gel. Phosphoric acid gel was applied directly from the syringe to cut enamel first, wait 15-20 sec, then applied to all exposed dentin for 15 sec. The etchant gel was rinsed off with a stream of water for

15sec, preserving a clean, contamination-free field. After gentle air drying for 1 second, a moist dentin surface was dried gently using oil free air. Teeth were subdivided randomly into three subgroups (n=10) according to the restorative material used. Adhesive procedures were performed following manufacturer's instructions.

Each restorative material was used with its corresponding adhesive system follow:

a. Incremental layering using Filtek Z250:

Immediately after blotting the excess moisture from the dentin by gentle air drying, two coats from single bond adhesive were applied with gentle agitation using a fully saturated applicator; with 20s waiting period in between the coats. Gentle air thinning was performed for five seconds to evaporate solvents, and then light cured for10seconds.

The composite resin was applied incrementally in two horizontal increments with approximately 2-mm thickness. Each increment was gently condensed with clean non sticky composite condenser in order to ensure complete adaptation to the underlying resin and tooth structure (Optrasculpt modeling tip, Ivoclar/Vivadent). The occlusal anatomy was shaped as exactly as possible avoiding overhangs. Each 2-mm increment was irradiated for 40 seconds with the LED with curing tip touching the slopes of the cusps of the tooth. After removal of the matrix curing from the facial and lingual aspects of the proximal boxes to ensure complete polymerization. The light intensity of the curing unit was periodically checked with radiometer and was found to be constantly above 800 mW/cm^2.

b. Tetric EvoCeram bulk fill

After acid etching a single layer of ExciTE F adhesive was applied to the etched surfaces and scrubbed for 10 seconds. Then the excess material was removed with a gentle stream of air and light-cure for10 seconds**.** The entire cavity was filled with single increment, adapted to the cavity with condenser and the light cured with LED curing unit.

c. SonicFill technique

After gentle air drying with air for 1 second two coats of the adhesive were actively applied for 15 seconds with a saturated brush tip to the enamel and dentin, until the surface appeared glossy. Air thin for 3 seconds and the adhesive was light-cured for 20 seconds with a visible light unit.

Resin was applied to the cavity with the assistance of a specially designed sonic hand-piece. The customized composite is provided in a uni dose capsules. The hand-piece was attached to the air-water line by using a coupler adaptor, and then activated by the traditional rheostat pedal. The rate for dispensing resin composite was set with the switch at the base of the hand-piece by numbers from one to five (one is the slowest and five is the fastest, the mode rate speed was used by adjusting the rate to be on number three). SonicFill uni dose tip was inserted in the SonicFill handpiece with moderate hand pressure and screwed tightly in a clockwise rotation.

With the unidose composite tip in the proximal portion of the cavity, to avoid air trapping, the SonicFill handpiece was activated by depressing the foot pedal, the cavity was filled. With the help of sonic energy vibration, resin composite was extruded in a soft, nearly flowable as the viscosity drops by 87%. Once the cavity was filled and the handpiece was removed, composite begin storages in its original high viscosity state. A small diameter 1.5mm tip allows access to very small cavities.

The handpiece was slowly withdrawn as the cavity was filled, with the tip staying within the material to ensure well adaptation and avoid entrapment of air.

A round-ended condenser (Optrasulpt) was used to press down on the material and wipe away excess at the margins. SonicFill composite resin material is non-sticky and does not slump, so quick and easy sculpting and carving to the desired anatomical form was made with a bladed instrument. Upon completion, the restoration was light-cured from the occlusal for 20 seconds with a curing light providing high output. After removing the wedge and matrix, the restoration was light-cured again for 20 seconds from the buccal and the lingual aspects.

After applying the restorative materials, finishing and polishing with politip-P (Politip-p,IvoclarVivadent); step one finishing with gray cup and step two polishing with green one. The teeth were cleaned and impressions were taken by polyether impression material. By using wider PVC filled with the polyether impression material, the crown of the tooth is embedded under gentle pressure in the soft polyether and left to set, then teeth was removed from the set impression. The epoxy resin was mixed in a glass cup 1:3 (catalyst to base), eliminate the air bubbles the impression was poured on a vibrator and left for 12 hour for complete setting.

Replicas were produced after complete setting of the epoxy resin. The replicas were gold sputtered, quantitative and qualitative marginal analysis were carried out using SEM at 200x magnification. Marginal micrographs were evaluated for the following: continuous and non-continuous margin along the outer periphery of the restorations. The overall margins were investigated and the maximum gaps were measured, the margins were given scores on the basis of the following criteria:

- Score 0: No marginal gap formation.
- Score 1: Maximum marginal gap <30µm. [18]

All the collected data were subjected to statistical analysis using the statistical package for Social Science (SPSS Inc, Chicago, IL, US).

RESULTS

Table 2. Proportion of samples showing marginal in all three groups.

Marginal adaptation	GroupI (FiltekZ250)	Group II (TEBF)	Group III (SF)
Score 0	9	9	10
Score 1	1	1	0

Table 3. Kruscal-Wallis test comparing marginal adaptation of the tested group

Groups	Mean rank	
Group I	16	
Group II	16	
Group III	14.50	
Test Value	Chi-square	1.036
	P-Value	0.596

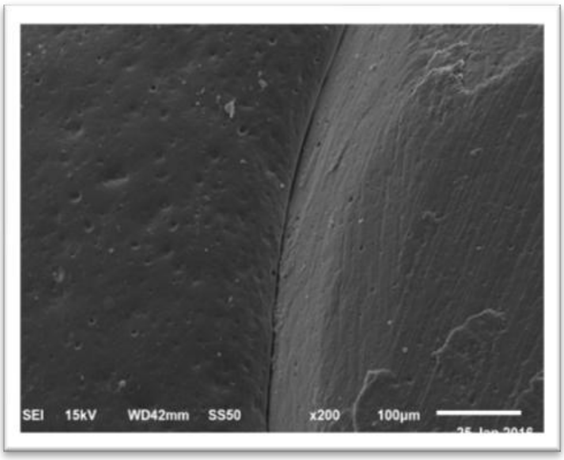

Fig 1. Representative SEM (200x) image of continuous margins of Z250 specimen.

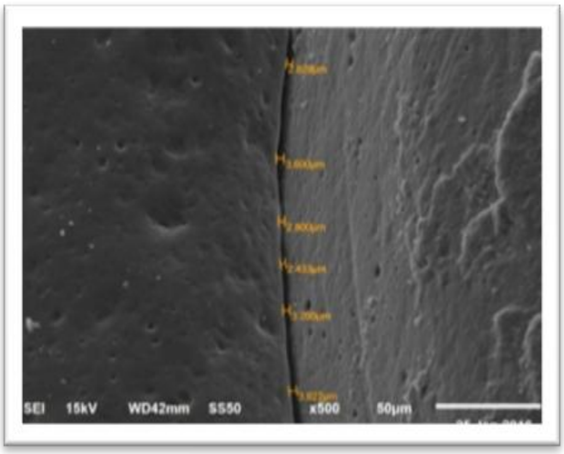

Fig 2. Representative SEM (200x) image of non-continuous margins of Z250 specimen (gap of 4µm).

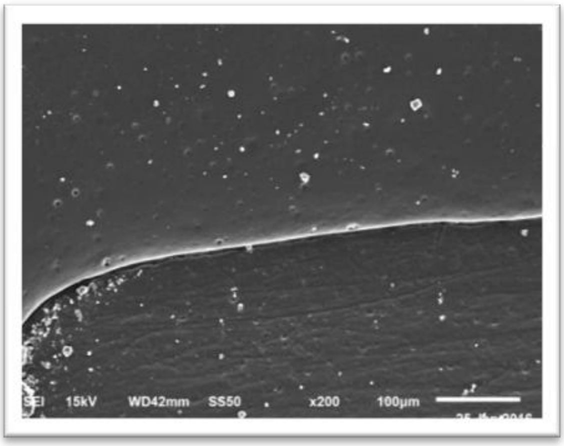

Fig 3. Representative SEM (200x) image of continuous margins of TEBF specimen.

A descriptive analysis of marginal adaptation was made for each of variables of the three groups (Tables2&3). There were no significant differences ($P<0.05$) between the tested bulk fill restorative materials (Sonic Fill and Tetric EvoCeram Bulk fill) and the conventional one (Filtek Z250).

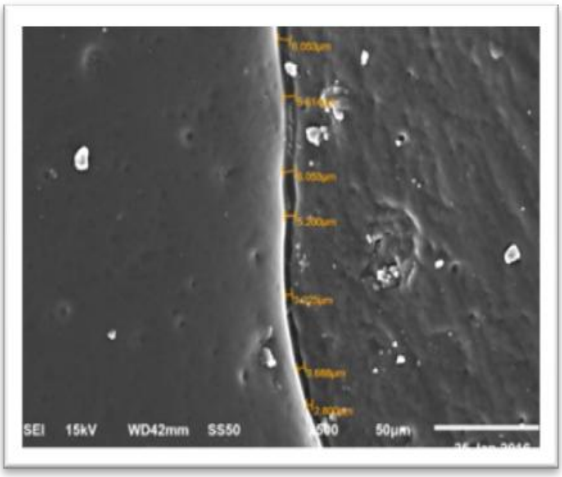

Fig 4. Representative SEM (200x) image of non-continuous margins of TE specimen (gap of 5µm).

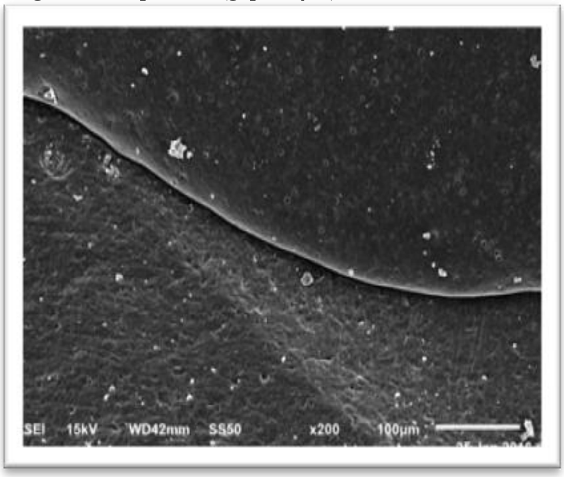

Fig 5. Representative SEM (200x) image of continuous margins of SF specimen.

DISCUSSION

Composite success story has been driven, not only by the patient demand for aesthetic universal filling materials, but also by continued industry-led product development and improvement of physical, mechanical, aesthetic and handling properties of both adhesives and composites. Despite the great improvements and the wide use in restoring posterior cavities, composite restorations still represent some short-comings as polymerization contraction and obtaining a tight contact point.

During an incremental layering technique, the composite resin material is gradually placed in layers of 2 mm or less. [27-30] This approach has a number of advantages; such as, it results in better light penetration and better polymerization of the composite resin, reduction of the cavity configuration factor, [31] cuspal deflection, [32] polymerization shrinkage stresses; and ensure that the resin adheres better to cavity walls. However, in addition to these advantages, there are a number of disadvantages associated with the use of incremental approach to apply resins in the cavity; for example, voids can be trapped between the increments, [10] bonding failure could occur between the increments, it can be difficult to place composite after conservative cavity preparation, and the time taken to complete the procedure is more lengthy due to the time required to place and polymerize each increment. [32]

Dentists have always been looking for a fast and reliable filling technique. Bulk-fill composites are resin-based, tooth-colored restorative materials that can be inserted into prepared cavities in layers that are up to 4 or 5 mm thick. [33] are characterized by increased polymerization depth, [34] decreased polymerization shrinkage stresses, [35] and cuspal deflection rates. [36]

Bulk fill RBC materials have been developed to enable dentists to reduce placement time and work more efficiently. Little information is available about the performance of this new bulk fill RBC, therefore, the current study was conducted to evaluate and compare the external marginal adaptation of MOD cavities restored with two bulk fill materials.

Absolutely perfect marginal seal is not achievable but a good marginal quality should be a main objective for all the clinicians. Marginal adaptation of a restoration to the tooth structure can be measured by either micro-leakage measurements or marginal adaptation measurements. Marginal adaptation has been chosen for this study in order to provide a quantitative analysis of the amount and width of gaps formed at the margins and marginal irregularities instead of the qualitative isolated analysis provided by microleakage. Butt-joint, clean-cut non-beveled preparation in the occlusal cavities was preferred in this study, because beveled cavosurface outline preparation results in a thin margin of composite resin which may fracture, leaving a ledge-typed effect at the marginal region. [37]

Examination of marginal adaptation between different specimens was made using the scanning electron microscope. Positive epoxy resin replicas were prepared for the purpose of this study. The decision to use replicas was made based on several studies. [38] Studies involving SEM reported that the technique of replicas was more accurate and precise for detecting marginal gaps than testing the dental tissues directly since, direct technique may cause specimen dehydration and shrinkage leading to widening of gaps. The current study showed some disadvantages of the epoxy resin replicas compared to direct examination of dental structure. Fabrication of resin replica was time consuming and some specimens had voids or excess epoxy resin. Specimens with voids related to the margins were sorted out and the replicas were remade. [39] The epoxy resin replicas were examined under the SEM at a magnification of 30X in order to view the entire cavity margin and to confirm accuracy of preparation and polishing of the restorations.

Then images were taken using a magnification of 200X. This magnification was necessary to discriminate between the different gap criteria, and was chosen based on other studies which have examined the external marginal adaptation of different dental restorations under the same magnification of 200X. [40-43]

The results of the current study showed continuous margins for all three tested groups except one specimen for Z250 showed 2µm gap and one for Tetric Evoceram bulk fill measuring 4µm. this means that bulk fill composite materials seems to satisfactory meet the requirement of this type o materials in terms of marginal adaptation.

For Z250 restored cavities the good marginal adaptation may be due to the incremental build up of composite resin which could result in reduction of the cavity configuration factor, better light penetration and polymerization of composite resin and ensures better adhesion of composite resin to the cavity walls. [44,45]

For Tetric EvoCeram bulk fill these results may be due to the slight increase in the filler content, or due to the enhanced modulus of elasticity and the decreased polymerization shrinkage of these materials. Another reason could be due to decreased viscosity of the bulk fill materials by modifying the monomers by adding hydroxyl free BIS-GMA and highly branched methacrylates which make them adapt well although placed in bulk not in increments. [46,47] Tetric EvoCeram bulk fill contain shrinkage stress reliever which are fillers with low modulus of elasticity (10MPa).These fillers works on keeping chemical cushion between the coarse filler particles and improves the elasticity of the restoration.

Also Tetric EvoCeram bulkfill contains new highly sensitive and reactive light initiator systems (Ivocerin) in addition to familiar initiators such as camphorquinone and acyl phosphine oxide. This new polymerization booster is based on dibenzoyl germanium derivatives, features with an absorption spectrum similar to that of the widely used camphorquinone. Ivocerin shows improved quantum efficiency due to its higher light absorption rate in the visible wavelength range and so higher light-reactivity. As a result, even very little light (photons) can trigger polymerization and achieve a high depth of cure. For SonicFill composite resin the good marginal adaptation may be due to their flow consistency during application. A study made by Peutz feldt et al stated that the degree of fluidity when applying composite resin enhances the marginal adaptation and results in better adhesion to the cavity walls. [37] SonicFill composite resin is highly filled (83.5%wt) this increased filler loading may decrease polymerization shrinkage stresses allowing good marginal seal at the restoration tooth interface. The ability of sonic fill composite to behave like flowable composite during placement and it provides better adaptation to cavity walls.

The results of the present study are in agreement with other studies comparing the different placement techniques (layering versus bulk filling) with different RBC systems [48,49] Similar results were also stated by studies where the comparison was made in the placement technique (layering versus bulk) using only conventional RBC systems. [50]

The results of the present study differed from a study conducted by Mullejans et al. comparing the technique of placement (layering versus bulk) using one conventional RBC showed that incremental placement decreased the marginal gap formation. This difference may be due to the fact that only conventional RBC was used and the types of RBC systems used were different. It is also important to mention that the present results were obtained in the *In vitro* condition means; very good capability of light curing unit and direct access to the prepared tooth-composite sample. [51]

CONCLUSION

Based on and within limitation of the present study, the following conclusions can be assumed:-

1. The tested bulk fill resin based composites and conventional layered one showed good marginal adaptation.
2. All the tested restorative systems (Z250, TEBF and SF) failed to achieve polymerization shrinkage free conditions.

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