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Microleakage Difference between Bulk and Incremental Technique on Bulk Fill Resin Composite Restoration (in Vitro Study)

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Abstract

Polymerization shrinkage is one major drawback of composite resin as dental restoration material. Polymerization shrinkage can cause microleakage that may impact on the occurence of secondary caries. Incremental placement technique has been widely suggested as an attempt to minimize polymerization shrinkage. Meanwhile, developments in dentistry has led to bulk fill composites that can be used up to a thickness of 4 mm with less polymerization shrinkage compared with conventional composites. Aim: To determine microleakage difference between bulk and incremental technique on bulk fill resin composite restoration.

Cavity depth of 4 mm with diameter of 2 mm were made on two sample groups, each group consisted of 12 premolars. Group 1 with bulk technique (4 mm) and group 2 with incremental technique of 2 layers (2 mm) horizontally. Samples were submesed in 0.3% methylene blue for 24 hours. Samples were cut in bucco-lingual direction and microleakage determined with scoring system.

There were significant differences between sample groups ($p < 0.05$). In general, microleakage produced by incremental technique was smaller than bulk technique.

Incremental technique on bulk fill resin composite restoration creates less microleakage than bulk technique.

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Keywords: Bulk fill composite, microleakage, bulk technique, incremental technique, polymerization shrinkage.

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Introduction

Composite resin is a restorative material that was introduced in the 1960s by Bowen. Since then, the composite resin has undergone many developments until now. However, conventional composite resins have several drawbacks, including shrinkage and stress due to polymerization processes, marginal microleakage, post-operative sensitivity, wear, discoloration, low fracture resistance, caries recurrence and tooth deformation.[1,2] Large posterior composite restoration has high failure rate, secondary caries incidence, and therefore higher retreatment frequency.[3] One of the most common causes (about 73.9%) of restoration failure was secondary caries.[4,5]

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Secondary caries is defined as caries on tooth surface under the restorative material. Secondary caries can be found on the enamel surface around the restoration material or extends along its margins.[6] This may results from marginal microleakage arising from poor marginal adaptation of composite resin due to polymerization shrinkage, thus causing post-operative tooth sensitivity and bacterial invasion of Streptococcus mutans.[2] Contraction force due to light cure polymerization will compete with the adhesion force between tooth structure and composite resin, thus able to break the bond between the composite and the tooth structure and therefore form a marginal gap. Marginal gap may become the entry for bacteria and eventually develop into secondary caries.[7]

In terms of direct restoration for deep cavity, there are three major challenges, namely

the depth of cure limitations that limit the thickness of the composite placement, the shrinkage due to setting reaction, and the manipulation of proximal contact with adjacent teeth. When the composite resin is placed thicker than the depth of cure according to the manufacturer then the polymerization will not be optimal. This will also result in greater polymerization shrinkage and increase the risk of secondary caries.[8]

Currently, almost all commercially available composite resins have the basic properties of polymerization shrinkage due to the methacrylate-based monomer composition. One of the well-known techniques to reduce polymerization shrinkage is incremental curing that can produce less marginal leakage compared to a single curing on conventional composite resins.[9]

The development of dental materials has led to the increasingly popular methacrylate bulk fill composite because of certain properties, including good flow, good elasticity, smaller shrinkage, and high degree of conversion which allows penetration of light up to 4 mm depth.[10] Less polymerization shrinkage on bulk fill composite resins is due to the addition of special modifiers that can reduce stress of polymerization process.[1]

Incremental curing technique have been shown to reduce microleakage on hybrid composite resins. Sakri *et al.,* found that in incremental techniques with a 1 mm thick layer in a 2 mm cavity having less edge leakage than without incremental.[11] Zorzin et al., have also observed that two increments curing can minimize polymerization shrinkage and increase degree of conversion on bulk fill composite resin.[12] However, there are still a few researches on how variations in the amount of curing affect the microleakage of packable bulk fill composite resin. If incremental technique successfully minimizes the microleakage of bulk fill composite resin, it will simplify the application and become a time-saving alternative procedure in restoration because it uses only one type of material without liner or flowable composite.

Materials and methods

This research was a laboratory experimental with Post Test Only Group Design research design. The samples were 24 maxillary premolar teeth with completely formed roots, without caries, restoration, discoloration, or fracture. The sample size was calculated using the Hypothesis Tests for Two Population Proportions (one-sided test) formula. The samples were divided into two treatment groups, the first group (I) was single increment of 4 mm thickness (bulk technique) with single curing, and the second group (II) was two increments of 2 mm thickness with two-times curing. The composite used was Tetric N-Ceram Bulk Fill (Ivoclar Vivadent, Liechtenstein, Germany). The bonding agent used is Te-econom (Ivoclar Vivadent, Liechtenstein, Gemany) from the same manufacturer as well.

Sample Preparation

First the teeth were cleaned and rinsed with saline solution and then stored at room temperature.[13] Enamel of the occlusal was cut to remove the cusps. The cavity preparation of class I as deep as 4 mm with diameter 2 mm was made with low speed handpiece and cylindrical bur. The depth of the cavity was measured using a straight probe with a stopper as a marker.[14] Finishing of the cavity wall was done with a fine diamond bur.

Group 1: The cavity surface was etched with 37% phosphoric acid on the enamel margin cavosurface, washed, and dried. Total etch bonding was applied with microbrush and cured for 20 seconds. The cavity was filled with 4 mm-thick Tetric N-Ceram Bulk Fill composite, condensed with a plugger, applied celulloid strip to produce a flat surface, then cured for 20 seconds with an intensity of 600 mW according to the manufacturer's instructions.

Group 2: The cavity surface was etched with 37% phosphoric acid on the enamel margin cavosurface, washed, and dried. Total etch bonding was applied with microbrush and cured for 20 seconds. The cavity was filled with 2mm-thick Tetrill N-Ceram Bulk Fill composite measured with marked probe, condensed with a plugger, applied celulloid strips to produce a flat surface, then cured for 20 seconds with 600 mW intensity according to the manufacturer's instructions. The second layer was added later with thickness of 2 mm and cured for 20 seconds.

Submersion in Methylene Blue

After all the samples have been filled, the apex were covered with dental wax and the entire part was coated with two layers of nail polish except on the 1 mm around the restoration. Samples were incubated in physiological saline for 24 hours at 37 ° C using incubator. Sample then dried with tissue and submersed in a 0.3% methylene blue solution at 37 ° C for 24 hours in the incubator. After submersion, samples were washed with aquadest for 10 seconds then dried. The samples were cut in buccal-lingual direction starting from the occlusal surface at the center of the restoration to obtain mesial and distal sections. Fixation of every sample was done using the dental wax in block form and dye penetration was measured using the scoring method according to Popoff et al., as follows:[15]

0 = no penetration into interfacial-tooth-composite.

1 = dye penetration into interfacial-tooth-composite less than half of the lateral wall of the cavity.

2 = dye penetration into the interfacial-tooth-composite up to more than half the lateral wall of the cavity, but not affecting axio-pulpal wall.

3 = dye penetration into interfacial-tooth-composite along the lateral wall of the cavity and affecting the axio-pulpal wall.

4 = dye penetration into the interfacial-dental composite along the lateral wall of the cavity, affecting the axio-pulpal wall, and extending to the base of the pulp wall.

Observation was done using stereomicroscope (S02 1x-500x 2MP USB Digital Microscope Portable 8-LED Electron Endoscope Magnifier, China) at 40x magnification. Results of scoring were in the form of non-parametric ordinal data and analyzed using Mann-Whitney test.[16]

Results

Microleakage measurement was done by observation dye penetration at restoration of bulk fill composite resin then classified based on scoring criteria. The use of scoring as semi-quantitative method was considered to be the most representative method for microleakage study using dye penetration and sectioning method in two dimensions.

Based on Table 1, the result of group with bulk fill technique on 4 mm deep cavity showed score 0 in 2 teeth, score 1 in 9 teeth and score 4 in 1 tooth. The total number of samples in this group was 12 teeth. In the incremental technique group, out of 12 samples, 7 teeth scored 0 and the other 5 teeth scored 1.

Groups	Technique	Score					N	P
		0	1	2	3	4		
I	Bulk fill technique	2	9	-	-	1	12	0.012*
II	Incremental technique	7	5	-	-	-	12	

Table 1. Scoring results on methylene blue penetration into restoration.

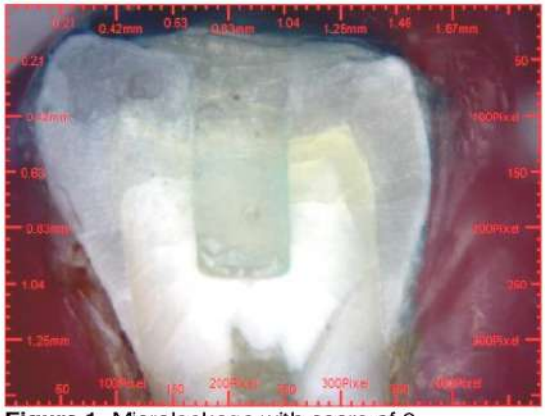

Figure 1. Microleakage with score of 0.

Mann-Whitney test analysis results showed that microleakage score of both groups had significant differences with value of $p = 0.01$ at $p < 0.05$. Group with incremental technique resulted in smaller microleakage compared to the bulk fill technique.

Discussion

Microleakage is one of the factors that play a role of failure in composite resin restoration. Microleakage occurred due to the break of bonding between cavity walls and restorative materials caused by polymerization shrinkage phenomenon. Composite resin bulk fill as an innovation in the development of composite resin, claimed to have minimal polymerization shrinkage, although placed in a deep cavity (4-5 mm).[17]

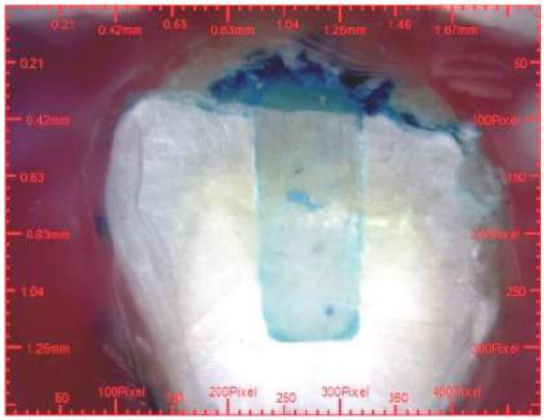

Figure 2. Microleakage with score of 4.

The polymerization of the composite resin occurs in two stages, the first being the activation of camphoroquinone (CQ) and the second is propagation reaction. During the first stage, CQ will be excited through activation with blue light (400-550 nm) therefore hydrogen from organic amine (co-initiator) will be attracted and form free radicals. Free radicals will react with monomer molecules starting from the center and polymerization reactions will continue to spread around it. The second stage is propagation involves adding chains through the addition of a cross-linked covalent monomer to a maximum degree of conversion. Maximum degree of conversion means the maximum number of unsaturated bonds (C = C) converted to saturated bonds (C-C).[18]

Initially, the distance between molecular monomers is about 4 A°. During the polymerization process, the distance is replaced by a covalent bond with a distance of about 1.5 A°. The volume contraction that occurs as small monomer units is converted into long polymer chains is called polymerization shrinkage. In composite resins, this shrinkage may range from less than 1% to 6%.[18]

Polymerization shrinkage will cause shrinkage stress on the interfacial surface of composite resin with enamel & dentin structure. The amount of stress is estimated at 13-17 Mpa. The application of bonding agent is an attempt to compensate the stress shrinkage because it can increase the adhesion bond strength between composite resin and tooth structure up to 20 MPa.[19] However, the strength of the polymerization contraction in gross total can exceed the bonding strength, therefore causing detachment of the bonding and produce a microscopic gap that prone to caries recurrence.[20]

The bulk fill composite used was Tetric N-Ceram Bulk Fill from the Ivoclar Vivadent. Tetric N-Ceram Bulk Fill is classified as packable due to its large filler particle proportion (73.1%) and is indicated for posterior restoration. The unique feature of this composite compared to other bulk fill composites is the addition of Ivocerin, a photoinitiator. Ivocerin was claimed to have better light absorption properties compared to CQ.[21]

The curing technique may affect the depth of cure of the composite resin. Therefore, the light curing unit, light intensity, wavelength, and radiation distance were controlled to create the same treatment for all samples. The intensity of light and wavelength used was adjusted to the manufacturer's instructions above 500 nm with a wavelength of about 450 nm. Based on Dunne & Millar, the closer the radiation distance is, the greater the depth of cure of the composite resin.[22] Therefore, the irradiation was as close as possible (attached to the surface of the composite resin) in order to obtain maximum depth of cure.[16]

Microleakage was observed through the penetration of methylene blue on the interfacial surface of the bulk fill composite resin with the cavity wall. Methylene blue was used due to its low molecular weight, affordable cost, and easy to use. The molecular weight of the methylene blue is lower than the average molecular weight of bacteria so it is considered representative enough to identify the microleakage of composite resin restoration.[11] The scoring method used to assess microleakage has been used in a study by Popoff et al.[15] The scoring method is considered a semiquantitative method because the assessment is based solely on the observation and interpretation of the observer. In addition, one of the limitations of this method is that it cannot quantitatively measure the microleakage because the sample cut is only done on one side (bucco-lingual) only. Nevertheless, this method is still acceptable and widely used to quantify microleakage semiquantitatively.[23]

The bulk technique group showed more samples subjected to microleakage compared to incremental technique. Meanwhile, in incremental

technique group, more samples found without microleakage (score 0). This is consistent with the study of Bugalia et al., which stated that incremental techniques produce smaller microleakage compared to bulk techniques.[24] Through incremental techniques, light penetration was optimized due to the reduced volume of the polymerized material, hence the light intensity that penetrated into the material was still high and therefore created optimal polymerization.[25] In accordance with the statement Anusavice, the thicker placement of a composite resin, the more light intensity reduced because of material density and absorption by composite resin material.[26] The addition of a composite resin second layer after placement of a first layer will compensate the shrinkage of the first layer by closing the gap due to the shrinkage of the first layer volume.[24]

Microleakage score of 1 also found in incremental technique group. It can be explained by Welime statement which stated that in incremental technique, it was possible that the volume of composite resin applied in incremental technique will be less than the initial volume.[25] Therefore, there would be deformity of the cavity wall which resulted in an interfacial gap. Many studies have attempted to examine incremental techniques that can produce the maximum marginal seal. In addition to the horizontal layering technique used in this study, there are several techniques that have been studied such as oblique, centripetal, and horizontal split techniques.[27] In this study, microleakage still found in entire experimental groups, but there was a significant difference between bulk technique and incremental technique. Microleakage observed in the incremental group was smaller than in bulk technique.

Conclusions

Restoration using incremental technique proved to result less microleakage compared to bulk fill technique. Therefore it was recommended for clinical use for composite resin restoration. Further research can be done to investigate more specific incremental techniques, such as incremental oblique and centripetal techniques. In addition, the biocompatibility of bulk fill packable composites in deep and adjacent-to-pulp cavities also need to be studied.

Declaration of Interest

None declared.

Conflict of Interests

Conflict of interests are declared none.

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