Comparison of microleakage from gingival wall restorations with and without sonically activated bulk-fill composite resins and incrementally layered composite resin: A laboratory experimental study

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Comparison of microleakage from gingival wall restorations with and without sonically activated bulk-fill composite resins and incrementally layered composite resin: A laboratory experimental study

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Abstract. One of the factors that determine the success of proximal composite restorations is a good marginal adaptation at the interface area. During polymerization, composite resin will undergo contraction which may cause gap formation between the wall cavity and restoration. The gap can cause microleakage and provide a passage for bacteria, fluid, molecules, and ions. The purpose of this study was to analyze the microleakage from gingival wall restorations with and without sonically activated bulk-fill nanohybrid composite resins and incrementally layered nanohybrid composite resins. Standardized Class II cavities were prepared on 30 extracted human upper and lower human teeth and were randomly assigned to three groups: filled with sonically activated bulk-fill composite resin, filled without sonically activate resin, and filled incrementally with resin. The specimens were stored in distilled water for 24 hours, were subjected to thermocycling, and were followed by immersion in 1% methylene blue dye for 24 hours. The teeth were sectioned longitudinally, were evaluated for microleakage under a stereomicroscope at 25x magnification, and were scored from 0–3. The Kolmogorov–Smirnov test was used to perform the statistical analysis. None of the techniques was capable of eliminating microleakage from gingival wall cavity preparations. There were no statistically significant leakage differences among the three groups.

1. Introduction

The ideal restoration material should have good adaptation to the tooth structure. A good benchmark for peripheral adaptation is the absence of leakage at the edge between the restoration and the natural teeth. A volumetric contraction of 2%–6% always accompanies the polymerization of dimethacrylate composite. The result will form a gap between the cavity wall and the restoration that triggers microleakage. This microleakage provides a path for bacteria, liquids, molecules, and ions to enter through the gap. Microleakage can lead to discoloration on the border of the tooth and restorations, secondary caries, and post-filled sensitivity [1–4].

To minimize the polymerization contraction, composite resins are continuously developed by modifying the fillers, such as their distribution, particle size, and matrix. The last developed type of composite resin, called a nano-composite, is made with particle sizes from 0.1 to 100 nm [5]. Restoration using a Class II composite resin can produce a good edge density if restricted to healthy enamel; however, the result will be different if the edges are located on the dentin, especially on the
proximal cavity gingival wall [6,7]. The bond of composite resin with enamel differs from the bond with dentin because of the differences in compositions and structures. Some characteristics of the dentin area are that the density of 1 mm dentinal tubules above the axial gingival wall is 49% larger than the cemento-enamel junction and the dentin in the cervix is more permeable than that in the occlusal area. The direction of the dentinal tubules in the proximal cavity gingival wall is largely changed structurally because of the formation of sclerotic dentin and reparative dentin. In addition, the dentin receives moisture from tubular fluid, gum pocket fluid, oral cavity fluid, residual acid flushing water, or the water content of the adhesive material [2].

One of the methods to reduce polymerization contraction that has been reported in proximal posterior restorations is the technique of placing composite materials. The technique that has been widely accepted is the incremental technique, which involves layering into the cavity [3,8,9]. This technique will decrease the contraction due to a decrease in the volume of the polymerized composite resin material. However, the technique is time-consuming and there is risk of air bubble formation or contamination between the layers; therefore, it is unable to cope with the microleakage [10]. The other technique of placing a composite material is by laying it all at once. The purpose of this technique is to shorten the time and to facilitate the filling [8,11,12]. A new bulk-fill composite material was developed by altering the photoinitiator and by using the sonic activation of bulk-fill composite resins [13].

This study aimed to compare the differences in the level of microleakage of gingival wall proximal restorations using nanohybrid composite resins with and without sonically activated bulk fill and resins that are incrementally layered.

2. Methods
This was a laboratory experimental study conducted at the Conservative Dentistry Clinic of Teaching Dental Hospital Faculty of Dentistry, Universitas Indonesia and the Biomedical Laboratory of Universitas Indonesia. The samples were 30 maxillary and lower premolar teeth corresponding to the inclusion criteria, while the materials used in this study included saline solution, sonically activated nanohybrid bulk-fill composite resin, nanohybrid bulk-fill high-viscosity composite resin without sonic activation, universal nanohybrid composite resin incrementally placed, etching material (35% phosphoric acid), adhesive material, 2% chlorhexidine, SIKMR, dye (1% methylene blue), and red nail polish. The tools used in this study included high-speed handpiece, 2.5x magnification, round and cylindrical diamond burs for high-speed use, periodontal probe, plastic filling instrument, metal matrix band, universal matrix, LED irradiation unit, applicator tip, microbrush, micromotor, polishing disc, thermometer, stopwatch, diamond disc, and stereo microscope with 25x magnification.

2.1 Cavity preparation
The specimens used 30 upper and lower premolar teeth that met the inclusion criteria. The shaped box Class II cavity was made on the mesial side of the tooth by using a cylindrical diamond bur. The width of buccal–lingual/palatal is 4 mm and width of gingival wall is 2 mm. The base of the gingival wall was placed 1 mm above the cervical line. The accuracy of cavity measurements was aided by the use of a periodontal probe and loops with 2.5x magnification. Then, the specimens were randomly divided into three groups consisting of 10 teeth each. In the first group, the cavity was restored with a bulk-fill composite resin with sonic activation (RBS group). In the second group, the cavity was restored with a bulk-fill composite resin without sonic activation (RBF group). In the third group, the cavities were restored with incrementally layered composite resins (RIK group). After the filling was completed, the restoration was polished by using polishing rubber.

2.2 Thermocycling and immersion specimens in 1% methylene blue dyes
Subsequently, the specimens were immersed in distilled water for 24 hours and, then, were subjected to a thermocycling procedure 250 times at 5 °C–55 °C manually for 1 minute with a rest period of 15
seconds. After thermocycling, the apex was cut 2 mm from the apex tip, was washed with water, was dried, and was filled with SIKMR. Then, all the tooth surfaces were treated with red nail polish by applying as much as two layers to a limit of 1 mm from the edges of the restoration. The specimens were immersed in 1% methylene blue for 24 hours at 37 °C in the incubator. Then, the specimens were rinsed under running water for 10 minutes and drained.

2.3 Cutting of specimens and observation of results

Next, the specimens were cut into two parts in the mesio-distal direction. From two parts of each tooth, one of them were randomly selected and examined under a stereo microscope equipped with a digital camera at 25 times magnification. Leakage was assessed by the following criteria: 0 = no penetration; 1 = penetration reached 1/2 of the gingival cavity wall; 2 = penetration reached more than half of the ginvial cavity wall; and 3 = penetration reached the cervical and axial walls of the cavity. The Kolmogorov–Smirnov test was used to perform the statistical analysis.

3. Results

Table 1 presents the distribution of microleakage in Class II gingiva wall restorations among bulk-filled sonic-activated, bulk-filled without sonic activation, and incremental technique. Of the total 30 samples observed, four (13.4%) had a score of 0. Of the remaining samples, four (13.4%) had a score of 1, 2 (6.7%) had a score of 2, and 20 (66.6%) had a score of 3.

Table 1 shows a comparison of each group with the total number of samples. In the composite resin with sonic-activated bulk-filled group, all the samples had a score of 3 (33.3%). In the composite resin bulk-filled without sonic activation group, two (6.7%) samples had a score of 0, two (6.7%) samples had a score of 1, none had a score of 2, and six (20%) had a score of 3. In the composite resin incremental group, two (6.7%) samples had a score of 0, two (6.7%) samples had a score of 1, two (6.7%) samples had a score of 2, and four (13.3%) samples had a score of 3.

The Kolmogorov–Smirnov test with a significance of p < 0.05 showed that there was no significant difference in microleakage in the gingival wall Class II restorations between the RBS group and RBF group (p = 0.400), between the RBS group and RIK group, (p = 0.055), or between the RBF group and RIK group (p = 0.988). Table 2 presents the mean values of the microleakage in the Class II restoration wall in the test groups.

| Composite resins group | Microleakage score | Total |
|------------------------|-------------------|-------|
|                        | 0 % | 1 % | 2 % | 3 % |       |
| RBS                    | 0 0 | 0 0 | 0 0 | 0 0 | 10 33.3 | 10 |
| RBF                    | 2 6.7 | 2 6.7 | 0 0 | 6 20 | 10 |
| RIK                    | 2 6.7 | 2 6.7 | 2 6.7 | 4 13.3 | 10 |
| Total                  | 4 13.4 | 4 13.4 | 2 6.7 | 20 66.6 | 30 |

n = total of sample; RBS = bulk-fill composite resin with sonic-activation; RBF = bulk-fill composite resin without sonic activation; RIK = composite resin applied by using an incremental technique.

| Composite resin group | P-value |
|-----------------------|---------|
| RBS vs. RBF           | 0.400   |
| RBS vs. RIK           | 0.055   |
However, the type of composite resin used in that study that of a amount of inorganic content and more water than susceptibility the was composite resin. Hence th

Discussion

sup < 0.05 - that there are a study.

The carbon double bonds which therefore, 0.988 consistent a study by Eunice et al restoration group with the gingival wall located on the enamel as polymerization contractions layered dentin [contracti restorat technique; significan the modulus of elasticity and volume contraction will adhesion of composite resin different from the the

Table 2. Continue

| RBF vs. RIK | 0.988 |
|-------------|-------|
| RBS = bulk-fill composite resin with sonic-activation; RBF = bulk-fill composite resin without sonic activation; RIK = composite resin incremental technique; significance level: p < 0.05 |

4. Discussion

Various commercially available composite resins have different matrix and filler compositions, which give different polymerization contractions. Some studies have recommended incremental placement techniques with a maximum thickness of 2 mm to reduce contraction. To shorten the working time, a posterior composite resin material that can be placed as bulk fill has been developed previously. This study used three types of composite resins that had the same type of filler: nanohybrid, which contained nano-sized particles (1–100 nm) with large particles (0.4–5 μm) [14,15]. Composite resins with nanoscale fillers have some of the advantages of smaller polymerization contractions, including better mechanical properties, better finishing and polishing qualities, and less susceptibility to wear and tear [16].

The gingival wall of a Class II cavity was chosen to assess the leakage because, often, there is no remaining enamel; therefore, the composite resin only binds to the dentin. Several factors make it difficult for composite resins to bond well to dentin, such as the dentin anatomy, the cavity configuration factor (C-factor), the dentin metalloprotein matrix, and the physical properties of the composite resin. The gingival wall has been shown to often have microleakage. Dentin has a unique anatomical aspect because it has a lower amount of inorganic content and more water than enamel has. The direction of the dentinal tubules of the proximal gingival cavity wall, most of which are parallel to the surface, also complicates the adhesion of composite resin to cavity walls [2,17], which is consistent with the study by Ozel et al. (2008) who reported that the microleakage in the composite resin Class II restoration group with the gingival wall located on the enamel was less than in the composite resin Class II restoration group with gingival walls located on the dentin [3].

In our study, there were no statistically significant differences in the microleakage of gingival wall Class II among the RBS, RBF, and RIK groups (see Table 2). The similar leakages were probably because the three techniques studied cannot compensate for the polymerization contraction that occurs because of changes in the dimensions of the composite resin. Hence, the hypothesis that microleakage of gingival wall Class II restorations between a bulk-fill sonic-activated resin composite is less than that of a bulk-fill resin composite without sonic activation and the microleakage of a bulk-fill resin composite with sonic activation is less than that of an incrementally layered resin was rejected. In addition, this rejection applies to the hypothesis that the microleakage from a gingival wall Class II restoration of a bulk-fill composite resin without sonic activation is greater than that of an incrementally layered resin. The results of this study are supported by those of a study by Eunice et al. (2012) that compared the microleakage of a sonic-activated composite resin with that of a nanofill composite resin that was incrementally layered. In our study, there was no significant difference in the microleakage between the restorations using resin with sonic activation and resin that was incrementally layered. However, the type of composite resin used in that study was different from the composite resin used in the present study.

Schneider (2010) stated that there are three important properties of composite resin related to the magnitude of contraction stress: the volume contraction, modulus of elasticity, and degree of conversion from the double carbon bond to a single carbon bond. Polymerization contraction stress depends on the relationship of the three components. When a composite resin is polymerized, it experiences volume contraction. At the same time, there will be an increase in the modulus of elasticity so that the plastic deformation ability is reduced and the composite resin becomes rigid. The more monomers with converted carbon double bonds that there are, the larger the number of units that form the polymer; therefore, the modulus of elasticity and volume contraction will increase [10,18].
5. Conclusion
There was no difference in gingival wall Class II restoration microleakage among composite resin using sonic-activated bulk fill, composite resin without sonic activation bulk fill, and incrementally layered composite resin.

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