A Comparison of microleakage at gingival wall in composite restoration using cocured and precured technique with conventional and modification liner: An in vitro study

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Abstract. Microleakage of composite restoration in proximal surfaces often occurs at the gingival wall. The purpose of this study was to analyze the microleakage at gingival wall in composite restoration using cocured and precured techniques with conventional and modified liner. Standardized class II cavities were prepared on 120 extracted human upper premolar mesial and distal fossae and categorized into four groups. Within box-like cavities, Group 1 was restored using a precured technique (conventional & modified liner), Group 2 was restored using a cocured technique (conventional & modified liner), Group 3 was restored using conventional liner (precured & cocured technique), and Group 4 was restored using modified liner (precured and cocured techniques). The specimens were subjected to thermocycling, followed by immersion in 1% methylene blue dye for 24 h. The teeth were sectioned mesiodistally and evaluated for microleakage under 25× magnification using a stereo microscope and scored using an ordinal scale (0–3). Statistical analysis was performed with the Kolmogorov–Smirnov test. Microleakage in Group 2 was significantly lower than Group 1 (p = 0.047). There was no significant difference between Group 3 and 4 (p = 0.985). The cocured technique showed lower microleakage than the precured technique. However, there was no statistically significant difference between conventional and modified liners.

1. Introduction

Proximal composite resin failure is caused by poor adaptation of the edge of the gingival region as the effect to polymerization contraction and high dentin content [1]. Achieving good bonding between composite resin and dentin is difficult due to the complicated morphology of dentin tubules, low mineralization, and heterogenic organic structure of dentin [2]. Contraction of composite resin may cause poor marginal adaptation of restoration resulting in microleakage, thus allowing bacteria, liquids, and toxins access to the dentin tubules, and causing dentin hypersensitivity, secondary caries, and pulp.
inflammation [3]. Many attempts have been made to minimize polymerization contraction of composite resin including the incremental filling technique to reduce the C-factor, soft-cure method or pulse–delay cure to decelerate the polymerization, and use of a liner with a low modulus of elasticity such as flowable composite resin [4].

Flowable composite resin has a low viscosity because it contains less filler than packable composite. It is more elastic, with a modulus of elasticity 20% to 30% lower than hybrid composite resin. The use of flowable composite resin as liners could reduce polymerization contraction based on the elastic cavity wall concept. This concept describes contraction stress caused by a high resin modulus that is absorbable by elastic intermediary layer, thus lessening the stress on the tooth–restoration surface [5]. Attar et al and Chuang et al showed that leakage on the gingival wall using composite restoration with flowable composite resin liner was lower than with the incremental technique. Conversely Oliveria et al showed that flowable composite resin has higher polymerization stress than incremental technique [3]. Modified flowable smart dentin replacement (SDR) (Dentsply, Konstanz, Germany) containing modified urethane dimethacrylate resin was recently introduced and reduce polymerization contraction by 60% to 70% compared with conventional flowable [6]. Natasha used modified flowable composite resin such as Surefil SDR (Dentsply, USA) as a liner and showed gingival margin leakage on proximal composite resin restoration with SDR liner was lower compared with the incremental technique [7]. A study on modified resin conducted by Czasch showed polymerization contraction was reduced by as much as 20% and pressure caused by polymerization was reduced by up to 80% compared with conventional packable composite resin [8].

The cocured/snowplow technique, is currently being developed and is a composite resin filling technique in which flowable and conventional composite resins are cured simultaneously. Studies conducted by Reddy et al. Sood et al. and Pomohaci et al. compared the cocured/snowplow technique with the procured technique (composite resin filling technique using flowable and conventional composite resins cured independently) and showed that the cocured/snowplow technique had lower gingival margin leakage compared with the procured technique [9–11]. The present study aimed to analyze and compare the extent of marginal leakage of proximal composite resin fillings using cocured and procured techniques using flowable composite resin and to analyze and compare the extent of marginal leakage of proximal composite resin using modified and conventional flowable composite resins.

2. Methods
This study was an in vitro experiment conducted at the Teaching Dental Hospital, and the Laboratory of Dental Materials, Faculty of Dentistry, Universitas Indonesia from July to August 2014. 60 samples of human caries-free posterior teeth were used, obtained from teeth indicated for extraction for orthodontic purposes and divided the wide occlusal surfaces into 4 groups containing 15 samples with 30 cavities for each group. Group 1 used the procured technique and group 2 used the cocured technique, while group 3 used conventional flowable resin composite and group 4 used modified flowable resin composite. Samples were cleaned to remove soft tissue and calculus using a scaler, rinsed under running water and kept in saline for a week prior to treatment. Cavity preparation was performed on the mesial and distal surfaces of each tooth: 4 mm bucco-lingual or bucco-palatal and 2 mm for the gingival wall. The base of the gingival wall was located 1 mm above the cementenamel junction (CEJ).

The materials used included 60 upper premolars in accordance with inclusive criteria, saline (NaCl 0.9%), ETSA gel, prime and bond adhesive, packable resin composite (Surefil, Dentsply batch no. 545221), conventional flowable resin composite as liner (Esthet-X-Flow Dentsply in syringe form), modified flowable resin composite as liner (Surefil SDR, Dentsply batch no; 020833 in syringe form), dyes (methylenic blue 1%), and green and red nail polish (Revlon ColorStay). The equipment used include
a highspeed hand piece, air and water syringe, 3× magnification loops, round diamond and cylindrical high speed burs, periodontal probe, Tofflemire universal matrix, metal band matrix, ball-pointed instrument (1 mm diameter), plastic filling instrument, LED light cure unit (Smartlite Focus, Dentsply) with 1100 mW/cm² wavelength, microbrush (1 mm diameter), Pogo polisher, thermometer, stopwatch, diamond disk, stereo microscope (Stereo Discovery, V12, Carl Zeiss) with 25× magnification equipped with digital camera (AxioCam).

Thermocycling was performed 250 times manually at 5°C to 55°C with an immersion time of 30 seconds and a resting time of 15 s for each cycle. For each specimen, a 2 mm apex was cut out using a diamond disk with a water cooler. Cavities were made on the apex using a low speed round metal bur, then rinsed with water, dried and filled with glass ionomer cement. The entire surface of the tooth, up to 1 mm from the edge of the restoration, was then coated with red nail polish twice. The first coat was left to dry for 1 h and procedure was repeated to apply a second layer.

Specimens were immersed in 1 % methylene blue for 24 h at 37°C in an incubator. Specimens were then dried and rinsed slowly under running water for 10 min and set aside. Specimens were cut mesiodistally into two identical parts using a high speed diamond disk.

A 1 % methylene blue penetration was observed on each specimen using a stereo microscope with 25× magnification, equipped with digital camera. Using the acquired micrographs, the distance of methylene blue penetration along the gingival margin was calculated using the AxioCam program. Data were compiled by two different observers who had been trained prior the study to achieve external validity and reliability.

Chi-square statistic test was used to analyze data and to compare the results between each group with p < 0.05.

3. Result
Data were compiled by one observer and was analyzed using Chi-square (expected count > 5 comprising less than 20% of data were not fulfilled). After the cell was combined, it was not eligible for Chi-Square; thus Kolmogorov–Smirnov test was used.

| Group | 0 | 1 | 2 | 3 |
|-------|---|---|---|---|
| 1     | 22| 18.33 | 6 | 5 | 0 | 0 | 32 | 26.67 |
| 2     | 37| 30.83 | 2 | 1.67 | 0 | 0 | 21 | 17.5 |
| 3     | 27| 22.5 | 6 | 5 | 0 | 0 | 27 | 22.5 |
| 4     | 32| 26.67 | 2 | 1.67 | 0 | 0 | 26 | 21.66 |

0 = no penetration
1 = penetration reached one-third of the gingiva
2 = penetration reached more than one to two-thirds of the gingiva
3 = penetration reached two-thirds of the margin of axial wall.

Table 1 shows that Group 2 had lower leakage compared with Group 1, and Group 4 had lower leakage compared with Group 3.
Table 2. Significance of difference between proximal gingival margin leakage between each group

| Resin Composite Group | p-value |
|-----------------------|---------|
| Group 1 vs Group 2    | 0.047   |
| Group 3 vs Group 4    | 0.985   |

*p<0.05
**p>0.05

The results of the Kolmogorov–Smirnov test (Table 2) showed a significant difference between Groups 1 and 2 (p = 0.047). However, there was no significant difference between Groups 3 and 4 (p = 0.985).

4. Discussion

Gingival marginal leakage of proximal restoration frequently happens due to difficulties in achieving good bonding between the tooth and the composite resin in this area. This is caused by the morphology of dentin and polymerization contraction [12,13]. Gingival marginal leakage allows access to bacteria, liquid, or other molecules that may induce a pulp reaction. Therefore, we investigated the differences in gingival marginal leakage of proximal restoration using two filling techniques and two different liners.

Several methods including use of an incremental technique, use of bonding agents, variations in curing, using materials with low modulus of elasticity such as flowable resin composite had been done to reduce gingival marginal leakage of proximal restoration. Flowable composite resin used as liner could reduce restoration leakage due to their modulus of elasticity being lower than packable resin composite, thus it can serve as a stress absorbent during polymerization. Curing method for flowable liner application which has been used is procured technique. Packable resin composite application to flowable that has been cured could cause the occurrence of void between flowable and packable layer. This void is a disadvantage for the restoration, hence; the development of cocured technique. Good bonding between packable and flowable composite resin is achievable with this technique.

The present study was an in vitro investigation using the dye penetration methods that was introduced by Roulet et al. The microleakage research method used in the present study used 1% methylene blue dye. This dye was chosen over other leakage detector dyes (Indian dye, basic fuchsin or silver nitrate) for its small molecules (0.059 nm), smaller than bacteria (0.5–1µm), allow deeper penetration compared with other dyes [14–16]. Microleakage allows access for molecules or ions [18]. However, the penetration method using 1% methylene blue dyes can overcome the limitations of the bacteria penetration method since bacteria are too large to penetrate.

The present study used maxillary premolars that had been extracted for orthodontic purposes. Identical samples were selected to minimize anatomical variations between subjects. Teeth were immersed in saline to maintain the humidity, particularly for collagens in the dentin, and so as not to influence the hardness of dentin, and recreate similar condition to those of oral cavity environment as suggested by Mal et al. [17].

All cavities were prepared as box shapes on the mesial and distal proximals, with the base of the gingival wall located 1 mm above the CEJ. This was based on research conducted Korkmaz et al. that stated that proximal cavities in the gingival area located 1 mm above the CEJ showed lower marginal leakage compared with cavities located 1 mm below [17,18].

One factor that could reduce gingival margin leakage is the adhesive system. The two-step etch-and-rinse adhesive systems combine the primer agent and bonding in one bottle. It is important to etch the surface of the enamel and dentin to gain optimum bonding between the tooth and restoration [19].
Phosphoric acid was applied to the enamel and dentin to scrape off the smear layer and to demineralize the superficial dentin layer with the etch-and-rinse system. After etching, the monomer resin liquid and organic acid penetrates the etched dentin and produce surface bonding. Two-step etch-and-rinse system was developed to reduce the three-step etch-and-rinse system for composite restoration filling [20]. Boeckler et al observed that class II restoration with two-step etch-and-rinse system had a 4 % failure rate over 4 years. Other research conducted by Affarwal et al showed that flowable composite resin used as a liner with the two-step etch-and-rinse adhesive system could increase the integrity of the restoration edge [21].

Thermocycling was used to obtain similar restoration conditions in the oral cavities that underwent constant thermal change. Differences in thermal expansion coefficients between tooth structure and restoration material would cause an increase of gingival marginal leakage of proximal restoration [22]. Thermocycling in this research was conducted 250 times at 5°C to 55°C temperature with 15 s resting time, which is half the recommendation of the International Organization for Standardization TRI 11450, which is 500 cycles at 5°C to 55°C temperature since the thermocycling procedures was performed manually. Other studies showed that teeth that underwent thermocycling procedures with a total of 250 than 500 cycles had the same results as teeth that underwent 500 cycles with 10 and 60 s exposure time [23,24]. Thermocycling could fatigue the bonding between the restoration and the tooth surface [25].

This study showed a significant difference in the gingival margin leakage between Group 1 and 2 (p=0.047). In Group 1, 22 samples (18.33%) had a score of 0, 6 samples (5%) had a score of 1, and 32 samples had a score of 3 (26.67%). In Group 2, 37 samples (30.83%) had a score of 0 score, 2 samples (1.67%) had a score of 1 and 21 samples (17.5%) had a score of 3. Group 2 had more of 0 than Group 1. Therefore, marginal leakage in Group 2 was lower than Group 1, and the difference was statistically significant.

The comparison between Groups 1 and 2 showed that the cocured technique (Group 2) had a significantly lower marginal leakage. This was due to the adaptation between two good restoration materials used in the cocured technique. Moreover, the liner used in the cocured technique was thinner compared with the procured technique since some of the liner flowed out of the cavity when the packable resin composite was applied on top of the flowable composite. Majety et al and Natasha showed that a 1 mm thickness of flowable resin composite liner was better than 2mm; however, the difference was not statistically significant. Flowable resin composite has less filler and contracts more if the thickness is increased [7,26]. Therefore, liner should be made as thin as possible to reduce leakage. Beside a thinner flowable layer, lower leakage of marginal restoration depends on a good balance between flowable and packable composite resin, which is achievable when being cured together, reducing the possibility of void formation. A void on the margin of the restoration will cause leakage and discoloration. Second, the initial stress concentration will start from the void area, causing lower tolerance to fatigue and increasing wear. Third, a void between the composite resin layers will negatively affect the flexure strength of the restoration material. Finally, a void can be visualized as a translucent area on a radiograph and may be interpreted as secondary caries.

Our study showed that gingival margin leakage between Group 3 and 4 were not statistically significant different (p = 0.985). In Group 3, 27 samples (22.5%) had a score of 0, 6 samples (5 %) had a score of 1 and 27 samples had a score of 3 (22.5%). In Group 4, 32 samples (26.67%) had a score of 0, 2 samples (1.67%) had a score of 1 score and 26 samples had a score of 3 (21.66%). Group 4 had more 0 scores than Group 3, but fewer scores of 1 and 3. Therefore, marginal leakage in Group 4 was lower compared with that of Group 3; however this was not statistically significant.

The comparison of Groups 3 and 4 showed that the modified flowable composite resin had lower marginal leakage although this was not statistically significant. This may be influenced by the urethane dimethacrylate resin in modified flowable composite that has lower polymerization contraction compared
with other type or resin. The resin in SDR include UDMA, TEGDMA, and EBPDM which have a lower viscosity than Bis-GMA monomer (and can also be found in Esthet X-Flow), thus better adaptation to the cavity. Moreover, modified flowable resin has more filler than conventional flowable. The higher the filler content in composite resin, the less polymerization contraction will occur. Furthermore, modified flowable resin monomer contains polymerization modulator that has flexibility; thus the shrinkage that happens during polymerization is less than with conventional flowable [7,8]. This result is in accordance with the findings of Arslan et al. who showed that modified flowable (SDR) resin had less leakage than other conventional flowable resins, although the difference was not statistically significant.

5. Conclusion
In conclusion the cocured technique reduced marginal leakage of proximal composite resin restoration compared with the procured technique. Use of modified flowable composite resin wash reduced the marginal leakage of proximal composite resin restoration compared with conventional flowable resin composite, although this was not significantly different.

6. References
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