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Marginal microleakage of composite resin restorations with surface sealant and bonding agent application after finishing and polishing

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Abstract. Microleakage at the marginal area of composite resin restorations can lead to discoloration and secondary caries. Performing rebonding after finishing and polishing can reduce microleakage of composite resin restorations. This study aimed to analyze the marginal microleakage of composite resin restorations after rebonding with a surface sealant and a bonding agent. Cavity preparation was performed on the buccal side of 60 human premolar teeth (3 mm in diameter and 2 mm in depth). Samples were randomly divided into two groups for rebonding with the different materials. Group 1 samples were rebonded with the surface sealant, whereas group 2 samples were rebonded with the bonding agent. Microleakage was measured using 1% methylene blue after thermocycling. Lesser microleakage was seen in group 1 than in group 2, with a statistically significant difference between the two groups ($p < 0.05$). Rebonding with a surface sealant can reduce marginal microleakage of composite resin restorations better than rebonding with a bonding agent.

1. Introduction

A survey conducted by the North American Dental School revealed failures in composite resin restorations, with problems such as secondary caries (53.60%), marginal leakage (18.20%), and discoloration (17.19%) [1]. This was in accordance with research conducted by Forss and Widstrom, who found that the most frequent causes of failure in composite resin restorations were secondary caries, marginal leakage, sensitivity, and aesthetic complaints [2].

Such problems may result from poor finishing and polishing procedures. The finishing and polishing procedure also affects the integrity of the edges of restorations, through the heat generated by the rotation of the instrument, and it can cause marginal leakage of composite resin restorations [3]. To address these problems, some clinicians perform rebonding after finishing and polishing using a bonding agent. The main purpose of a bonding agent is to create a stable bond between the restoration material and the tooth structure in order to close the gap [4]. A bonding agent is a bonding material consisting mainly of hydrophobic monomers such as bisphenol glycidyl methacrylate (Bis-GMA) urethane dimethacrylate, as well as hydrophilic monomers such as triethylene glycol dimethacrylate (TEGDMA) as a viscosity regulator and HEMA as a moisturizer with or without an additional filler [5]. Bonding can create effective marginal closure in composite resin restorations [6]. Rebonding with a bonding agent can prevent microleakage of composite resin restorations. Studies conducted on class V cavities of caries-free third molars, comparing a control group and a group that had bonding agents



applied after finishing and polishing concluded that rebonding with a bonding agent may reduce marginal leakage of composite resin restorations [7].

Currently, the development of a special material, known as a surface sealant, used to cover the marginal leakage is in progress. A surface sealant is an unfilled resin that contains Bis-GMA. Polymers are modified by adding low molecular weight monomers, consisting of TEGDMA and tetrahydrofurfuryl methacrylate, which help control viscosity and wettability. Thus, research has suggested that surface sealants can penetrate the microdamage under the surface and the interfacial gap, thereby obtaining marginal integrity and prolonging the restoration. One study reported the use of surface sealants during rebonding in composite restorations. The study focused on the buccal surface of the premolars, which were filled using a hybrid composite resin, and finishing and polishing was then done with an abrasive disc. A surface sealant was applied after finishing and polishing. In that study, the group that was given a surface sealant was more effective in terms of microleakage closure than the group that was not given a surface sealant. This was because the material could penetrate into the microleakage and interfacial gap that occurs as a result of finishing and polishing [8]. However, there have been no studies comparing the effectiveness of surface sealant and bonding agent application in resolving microleakage caused by finishing and polishing. In the present study, the aim was to analyze the microleakage of composite resin restorations and to compare the application of a surface sealant and bonding agent post finishing and polishing.

2. Methods

This was an experimental laboratory study conducted at the Conservative Dentistry Clinic, Teaching Dental Hospital, Faculty of Dentistry Universitas Indonesia and the Laboratory of Dental Materials Universitas Indonesia in August and September 2014. Thirty samples per study group were allocated for use. The type of sample used was human premolar teeth extracted for orthodontic use, with the inclusion criteria being upper and lower premolars that had been indicated for extraction by orthodontic treatment, and with an intact and caries-free crown. Sixty premolar teeth that met the inclusion criteria were cleaned of soft tissue and calculus with a scaler, rinsed under running water, and stored in saline solution prior to treatment. The samples were then randomized and divided into two groups.

Cavitation preparation was performed on the buccal or palatal surfaces of each tooth using a round bur and a fissure bur. The cavity size was 3 mm in diameter and 2 mm in depth. Periodontal probes were used to confirm the cavity depth.

After the formation of cavities was complete, etching was done on the cavity surface using Scotchbond Etchant (3M ESPE) for 15 s and then rinsed with water for 10 s. Excess water was removed with a mini-sponge. Bonding was then done with Adper Single Bond 2 (3M ESPE) by gently moving the applicator in a circular motion. The cavity was blown with light pressure air for 5 s to vaporize the solvent, and irradiation was done for 10 s. Then, the samples were filled using a nanofill composite resin and cured. Finishing and polishing was then done using a one-step polishing system (PoGo, Dentsply). A single instrument was used for three restorations. Group I (30 teeth) samples were treated with a surface sealant (PermaSeal, Ultradent). Group II (30 teeth) samples underwent rebonding using a bonding agent (Adper single bond 2, 3M ESPE). Thermocycling was performed on all samples (up to 250 times, at 5°C to 55°C, with a rest time of 15 s). The entire surface of the tooth was covered by two layers of nail polish, except for the part undergoing restoration and 1 mm from the margin of the restoration. The samples were soaked for 24 h at room temperature in 1% methylene blue solution, after which they were rinsed under running water. Samples were then split using diamond disks and water in midrestoration in the buccolingual direction and then observed under a stereomicroscope with 25× magnification. The microleakage scale follows the ordinal scale by Korkmaz et al (Figure 1) [9]:

- 0 = no dye penetration occurs
- 1 = dye penetration reaches one-third of the cavity wall
- 2 = dye penetration of more than one-third until two-thirds of the cavity wall
- 3 = dye penetration reaches two-thirds of the cavity wall until the cavity base

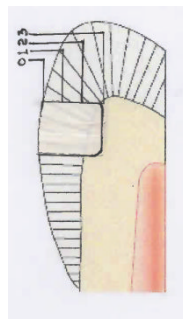


Figure 1. Dye penetration scheme

The Kolmogorov–Smirnov test was used to determine whether there was a difference in microleakage between surface sealant and bonding agent application.

3. Results

The effect of rebonding using a specific surface sealant and bonding agent against marginal microleakage of composite resin restorations and tooth structure was analyzed using a stereomicroscope with 25× magnification (Figure 2). The penetration depth of 1% methylene blue was measured and scored according to the scale proposed by Korkmaz et al. [9]. Observational data were analyzed using the Kolmogorov–Smirnov test.

The results of this research are shown in table 1. A score of 0 was seen most frequently in the surface sealant group (73.3%), a score of 1 was also seen most frequently in the surface sealant group (33.3%), a score of 2 was seen most frequently in the bonding agent group (33.3%), and a score of 3 was seen almost exclusively in the bonding agent group (96.7%). The microleakage scores on the margin of composite resin restorations after the application of rebonding material showed more distribution in the bonding agent group than in the surface sealant group.

Table 1. Marginal microleakage restoration values by group.

		Microleakage scale								<i>p-value</i>
		0		1		2		3		
		No.	%	No.	%	No.	%	No.	%	
Group	Surface sealant	22	73.3	1	3.3	0	0.0	7	23.3	<0.001*
	Bonding agent	0	0.0	0	0.0	1	3.3	29	96.7	

*Kolmogorov–Smirnov significance test with $p < 0.05$

At a significance value of $p < 0.001$ (Table 1), it can be concluded that there was a significant difference in microleakage between the surface sealant and bonding agent groups. Rebonding using the surface sealant was better in closing the microleakage at the margin of composite resin post finishing and polishing than rebonding using the bonding agent.

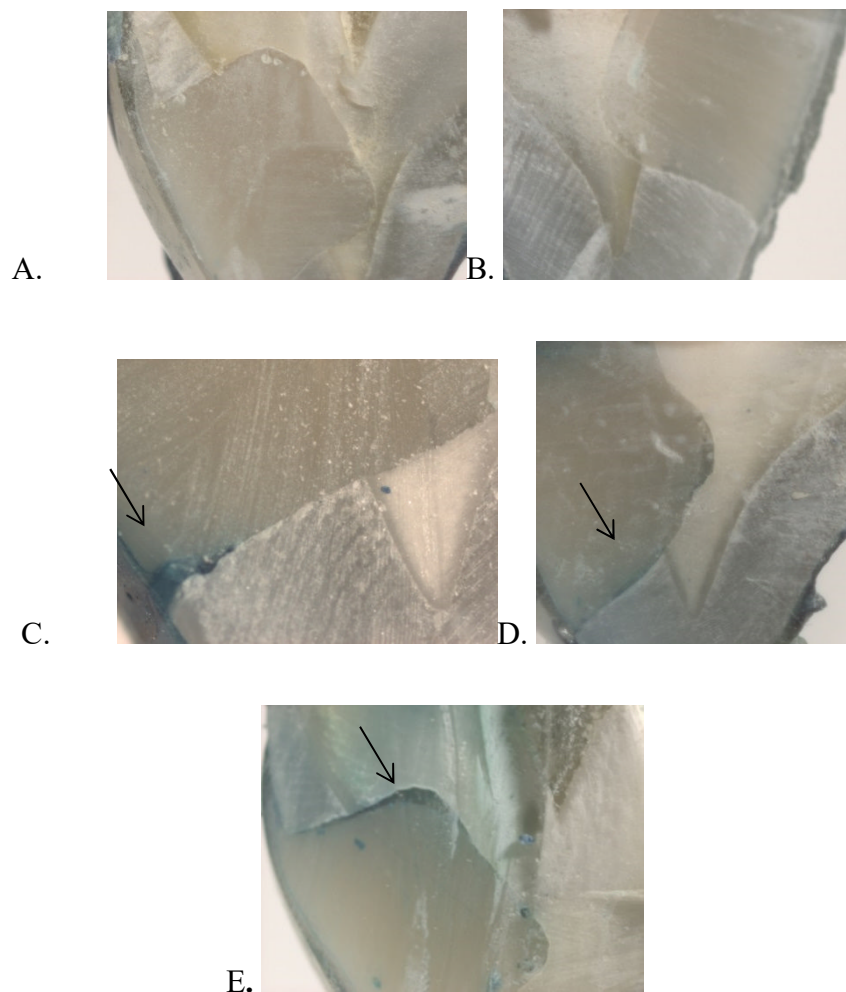


Figure 2. Representative image leak scores.

A, B. Score 0, C. Score 1, D. Score 2, E. Score 3. The arrow indicates leakage.

4. Discussion

This study analyzed marginal microleakage of composite resin restorations with surface sealant and bonding agent application after finishing and polishing. Small defects or microleakages are often found on the surface of composite resins. The defect may occur during surface finishing and polishing and will increase the roughness and wear rates of composite resin restorations [10]. Microleakage is the entry point for bacteria or other organisms that can cause secondary caries [11].

Microleakage occurs due to the formation of gaps on the surface, which can be caused by several factors such as (1) polymerization shrinkage, which causes tension in the area between the teeth and the restoration; (2) formation of microcracks at the margins and consequent defects or damage to the adhesion of the bonding material with the tooth structure; (3) differences in the thermal coefficient of expansion between the composite resin and the tooth structure; (4) use of nonincremental layering techniques; and (5) use of inadequate finishing and polishing procedures [10].

This study was an in vitro research using the dye penetration method. The study samples were 60 premolar teeth that were removed for orthodontic treatment. With the sample selection, we aimed to achieve sample uniformity and minimize anatomic variation. Teeth sampled in this study were immersed in saline water to retain dental moisture and simulate the oral state [12].

Dye penetration is the most frequently used method to observe microleakage. It is done by soaking specimens in a dye for a certain amount of time and then observing the margin between the teeth and the restorative material. In the present study, staining at the border area indicated microleakage. We

observed microleakage after soaking the samples in 1% methylene blue for 24 h after thermocycling. Methylene blue was used in the present study because it has a very small molecular size of 0.5–0.7 nm and is smaller than bacteria (0.5–1 μm), thus allowing the dye to penetrate further than other dye colour [13].

In the present study, thermocycling was applied to teeth samples to simulate restoration in the oral cavity with constant thermal changes. Thermocycling is an in vitro procedure performed to simulate restorations and the tooth structure at acceptable extreme temperatures in the oral cavity. In this study, thermocycling was performed in as much as 250 cycles at $5\text{--}55^\circ\text{C} \pm 2^\circ\text{C}$ with a resting time of 15 s and was done manually. According to Wahab et al. a small number of thermocycling cycles are sufficient to cause microleakage of composite resin restorations [14]. Another study found that after thermocycling, microleakage on the margin of the restorations was greater than that analyzed immediately after rebonding without thermocycling [13]. Thus, it can be concluded that thermocycling is effective in simulating the process of restoration.

Composite resin application in the present study was done incrementally using nanofilled composite. The reason we chose this material is because a nanofilled composite resin is one of the best composite resin materials currently available and because it is strong and has a high aesthetic value. These composite resins have better properties than the microhybrid type. This composite resin contains a filler, including nanofillers (containing 20–75-nm silica nanoparticles) and nanoclusters (containing zirconia–silica, 2–20 nm in size), such that it can be polished well, has good strength, and is easier to handle [15].

The acid etching system used in the present study was total etch. In the total etch system, the smear layer produced during dental preparation would be removed so that dentinal tubules are exposed and some collagen is exposed on the surface. The smear layer, which is a collection of dentine and salivary debris, can affect adhesive bonding between the tooth structure and the restoration material; therefore, it must be removed. One study found that the smear layer can block the bond between the dentin and the resin; the coating must therefore be cleaned properly [16].

The finishing and polishing procedure done in this study were immediate polishing. This procedure was selected because at present, immediate polishing is the most commonly used polishing procedure used in dental practice. The composite resin is polymerized when the material is exposed to light with a wavelength of 450–500 nm and polymerization will be complete within 24 h. The immediate finishing and polishing procedure can cause deformation because only approximately 75% of the composite resin material is subjected to hardening after 10 min. Damage to the composite resin can be seen as a white line, indicating the formation of a microgap at the enamel–resin interface immediately after finishing and polishing.

The formation of a microgap at the tooth–restoration interface can lead to the loss of marginal integrity. Rebonding is recommended as it can improve marginal closure through the application of a low viscosity resin. The resin infiltrates the interfacial gap to improve marginal region closure. The resin can also fill microdamage on the surface of the restoration, thereby increasing the wear resistance of the restoration and reducing the occurrence of secondary caries [17]. The rebonding technique can be performed using a bonding agent or a specific surface sealant. Specific surface sealants are materials intended to fix damage to the margin of composite resin restorations. A surface sealant contains unfilled resin (methacrylate) and a low molecular weight monomer and photoinitiator.

The effectiveness of the rebonding material depends on the flow rate and penetration depth of the material into the microstructure below the surface before polymerization. Research has indicated that the size of the gap that forms between the restoration material and the cavity surface of the teeth in the preparation is typically approximately 10–20 μm . Thus, bacteria can penetrate the gap and cause secondary caries. To fill in the interfacial gap, a resin with low viscosity (200 cp or less) is required for penetration prior to polymerization. To be able to wet well, the surface tension of the rebonding material should be lower than that of the restoration or tooth structure [17]. A smooth, clean, and dry surface free of saliva or the smear layer allows the material to moisten well to obtain good restoration cover. Bonding agents can contain filler particles that decrease the material's flow rate, thereby reducing the ability to wet the material on the surface [17].

Based on the results of the present study (shown in Table 1), it can be concluded that microleakage at the margin of the restoration was the greatest in the bonding agent group (score 3 as high as 96.7%). The significance value indicated that there was a significant difference between the type of rebonding material and marginal leakage. Rebonding using the surface sealant was found to be better in closing the microleakage at the margin of the composite resin after finishing and polishing than rebonding using the bonding agent. The results are in line with a study conducted by Lima et al. who conducted research on cow teeth and reported that fortified coatings (surface sealant) had better marginal closure results than other coatings (bonding agents) [18].

In the present study, marginal closure was better in samples with rebonding using a surface sealant than in those with rebonding using a bonding agent. This is because the bonding agent contained filler particles, which affected the viscosity as well as reduced the flow of material into microgaps that formed on the edges of the restorations and tooth cavities. The bonding agent used in the present study was Adper Single Bond 2 (3M ESPE), based on the description of the material of it containing as much as 10% of 5- μ m filler colloidal silica. The surface sealant used was PermaSeal (Ultradent), which contains Bis-GMA (60%) and TEGDMA (40%), without filler content, which has lower viscosity, and has better surface moisture capability. Specific surface sealants (PermaSeal) can penetrate into the microstructure of subsurface damage with better capillary action, resulting in homogeneous marginal integrity.

5. Conclusion

In rebonding, a surface sealant can close the microleakage on the margin of the composite resin restoration and the cavity after finishing and polishing better than a bonding agent.

6. References

- [1] Puckett AD, Fitchie JG, Kirk PC and Gamblin J 2007 Direct composite restorative materials *Dent. Clin. North Am.* 2007 **51** 659-75
- [2] Forss H and Widstrom E 2004 Reasons for restorative therapy and the longevity of restorations in adults *Acta Odontol. Scand.* **62** 82-6
- [3] Jefferies S 2012 *Polishing. Contemporary Esthetic Dentistry*. Ed G Freedman (St. Louis: Elsevier Mosby) pp. 267–85
- [4] Miyazaki M, Tsujimoto A, Tsubota K, Takamizawa T, Kurokawa H and Platt JA 2014 Important compositional characteristics in the clinical use of adhesive systems *J. Oral Sci.* **56** 1-9
- [5] Summit J and Robbins J 2001 *Fundamental of operative dentistry : a contemporary approach* (Philadelphia: Quintessence Publishing Co) p. 136, 178
- [6] Sirin Karaarslan E, Bulbul M, Yildiz E, Secilmis A, Sari F and Usumez A 2013 Effects of different polishing methods on color stability of resin composites after accelerated aging *Dent. Mater. J.* **32** 58-67
- [7] Tjan AH and Tan DE 1991 Microleakage at gingival margins of Class V composite resin restorations rebonded with various low-viscosity resin systems *Quintessence Int.* **22** 565-73
- [8] Youn YH, Hyun HK, Kim YJ, Kim JW, Jang KT, Lee SH, Kim CC and Hahn SH 2007 The effect of surface sealing on the microleakage of class v composite resin restorations *J. Korean Acad. Pediatr. Dent.* **34** 359-369
- [9] I. Yavuz, A.H. Aydin, R. Ulku, T.C. Dulgergil & M.Z. Akdag 2005 New Technique: Measurement of Microleakage Volume in the Marginal Gaps of the Dental Restorations, *Biotechnology & Biotechnological Equipment*, 19:3, 184-191
- [10] dos Santos PH, Pavan S, Assunção WG, Consani S, Correr-Sobrinho L and Sinhoreti MA 2008 Influence of surface sealants on microleakage of composite resin restorations *J. Dent. Child (Chic)* **75** 24-8
- [11] Braga RR, Ballester RY and Ferracane JL 2005 Factors involved in the development of polymerization shrinkage stress in resin-composites: a systematic review *Dent. Mater.* **21** 962-70
- [12] Purk JH, Dusevich V, Glaros A, Spencer P and Eick JD 2004 In vivo versus in vitro

- microtensile bond strength of axial versus gingival cavity preparation walls in Class II resin-based composite restorations *J. Am. Dent. Assoc.* **135** 185-93
- [13] Ahlberg KM, Assavanop P and Tay WM 1995 A comparison of the apical dye penetration patterns shown by methylene blue and india ink in root-filled teeth *Int. Endod. J.* **28** 30-4
- [14] Wahab FK, Shaini FJ and Morgano SM 2003 The effect of thermocycling on microleakage of several commercially available composite Class V restorations in vitro *J. Prosthet. Dent.* **9** 168-74
- [15] Chen MH 2010 Update on dental nanocomposites *J. Dent. Res.* **89** 549-60
- [16] Zivkovic S 2000 Quality assessment of marginal sealing using 7 dentin adhesive systems *Quintessence Int* **31** 423-429
- [17] Owents BM and Johnson WW 2006 Effect of new generation surface sealants on the marginal permeability of Class V resin composite restorations *Oper. Dent.* **31** 481-8
- [18] Lima AF, Soares GP, Vasconcellos PH, Ambrosano GM, Marchi GM, Lovadino JR and Aguiar FH 2011 Effect of surface sealants on microleakage of Class II restorations after thermocycling and long-term water storage *J. Adhes. Dent.* **13** 249-54