

Marginal adaptation of composite resin with different dentin bonding agents in Class V restorations

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ABSTRACT

Background: Esthetic concerns are the prime focus in modern restorative dental practice. Composite resin restorative materials have played crucial roles in establishing esthetics in many clinical situations. However, they are also prone for the marginal discrepancy and microleakage. Bonding agents are used to minimize this phenomenon to improve the success of the restorations. **Aim:** This study is to assess the marginal adaptation (MA) of nanohybrid composite resin with two 7th generation dentin bonding agents. **Materials and Methods:** A total of 40 extracted human maxillary premolars were cleaned, processed, mounted, and divided into two experimental Groups A and B. Class V cavities were prepared in extracted teeth with the gingival margin on the dentin and the incisal margin on the enamel. The cavities were restored with a nanohybrid composite resin (Swiss Tec Composite, Coltene Whaledent, USA) using the experimental self-etching adhesives, Group A - (Bond Plus SE, Medicept Dental, UK) and Group B - (Kerr OptiBond, Heraeus Kulzer, Germany). After that, the restorations were light cured, finished and polished. After thermocycling, the MA was analyzed using scanning electronic microscopy (SEM) (SEM, ×600 magnification). The outcome measure is the widest distance between the restoration and tooth structure in the cervical margins expressed in the micrometer. The discrepancy in each margin was recorded, tabulated and analyzed. **Results:** The mean discrepancy between tooth structure and restoration in Group A was 3.35 ± 0.31 μm and for Group B was 3.67 ± 0.24 μm . An independent sample *t*-test was used to analyze the data. A statistically significant difference was observed between the two groups ($P < 0.05$). **Conclusion:** Kerr OptiBond showed higher means of gaps than Bond Plus SE in the cervical margins. Even though a statically significance was observed between the two bonding agents, clinical significance may not be altered.

KEY WORDS: Bond pus SE, Class V, Kerr OptiBond, Marginal adaptation, Premolar, Scanning electron microscope, Swiss Tec

INTRODUCTION

Light-cured resin composites benefit today by an increasing spectrum of indications as their application has been expanded to include the restoration of anterior tooth wear^[1] and non-carious cervical lesions.^[2-5] The marginal seal of composite restorations represents an increasing concern in dentistry. Over the years, *in vitro* evaluations of resin adhesives revealed that microleakage and gap formation, mainly at the dentin-composite interface, did not improve at the same rate as did bond strength values.^[6-9]

Dentin bonding agents are widely used in dentistry nowadays increasingly. In view of this dentin bonding agent, research into the properties of the dentin bonding agent is more important and has to be considered. Bonding of composite resin to dentine occurs by means of infiltration and polymerization of hydrophilic resin into the collagen mesh exposed by acid treatment of dentin that forming a hybrid layer. Several authors have demonstrated degradation of the resin-dentin bond, and durability of resin cement.^[10] Independent of the bonding capacity of an adhesive system, it seems that adhesive restorations are far from assuring a perfect marginal seal, with degradation in time regardless of the products that are used.^[11] Marginal integrity is considered to be the result of several parameters related to the forces created by

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curing contraction, as bond strength alone could not be correlated to marginal adaptation (MA) in a study undertaken by Kemp-Scholte and Davidson.^[12]

Curing contraction has been shown to generate strain along the tooth restoration complex, leading to pre-stressed obturations, which are more prone to long-term degradation. The unfavorable effects of polymerization contraction forces can be evaluated effectively using marginal analysis, as marginal gaps offer proof of the forces generated by polymerization shrinkage or by thermo-mechanical strain, exceeding the bond strength.^[8] Other methods of assessing the effects of polymerization contraction are finite element analyses of the stress distribution measurements of tooth deformation and, recently, a three-dimensional deformation analysis.^[13-15]

The phenomenon of force development in contracting materials was first described in the dental literature by Bowen.^[16] The combined action of several stresses on the restoration-tooth interface on the remaining tooth structure creating enamel fissures, fractures.^[17]

The dimensional modification due to shrinkage depends on the number, size, and functionality of the monomers as well as on the filler load. The volumetric contraction undergoes two phases: The phase before and after the gel point. During the first phase, the resin retains its capacity to flow, and, therefore, it compensates the contraction forces by rearrangement of the molecules by preventing strain that would otherwise develop at the interfaces. During the second phase; however, the contraction forces are directed toward the bonded surfaces, leading to, among other things, and defects in the MA. These defects occur when the elasticity of the material is not sufficient to compensate for the contraction forces, thus allowing for stress to develop at the interface of the tooth restoration complex.^[13]

Flexibility is defined as the ability of a material to strain without becoming permanently deformed.^[18] The higher the elastic modulus and the polymerization shrinkage of the restoration, the higher the contraction stress.^[19] According to physical law, as low elastic modulus plays an important role in the stress relief becoming a desired property of the restorative material. It is assumed that increased flexibility would lower stress values on the interface. The elastic modulus and contraction are related to the filler content; higher filler load would lead to a lower contraction but cause an increase in hardness.^[14] A way to overcome this difficulty within material composition involves the use of a suitable dentin bonding agent and the restorative material. If stress exceeds the bond strength between the tooth structure and adhesive system, a contraction gap will be formed, and the reduce the restoration longevity.^[20] Hence,

this study was formulated with the aim to assess the effect of 7th generation dentin bonding agents on MA of nanohybrid composite resin.

MATERIALS AND METHODS

This study is to identify the MA of Class V restoration with two 7th generation bonding agent on 20 premolars for each dentin bonding agent, and Class V cavity was made. After that application of dentin bonding agents (Bond Plus SE, Medicept Dental, UK) Group A on 20 premolars and -(Kerr OptiBond, Heraeus Kulzer, Germany) Group B on other 20 premolars, a the restorations were carried out with nanohybrid composite resin (Swiss Tec Composite, Coltene Whaledent, USA). Then, the quantitative analysis is carried out under scanning electron microscopy, and the results were given by the widest distance between tooth structure and the composite resin in the cervical margins.

Cavity Preparation

One V-shaped normal Class V cavity was made on the buccal surface of each tooth with half margin in enamel and half in dentin. Tooth preparation was done using diamond bur with continuous water coolant. The dimensions of each cavity range from 3.0 to 3.5 mm by length, 2.5–3.0 mm in height, and 1.5 mm in depth. Finally, the cavity was finished, and the cavity was checked for marginal imperfections such as cracks and fractures, and the restoration was made.

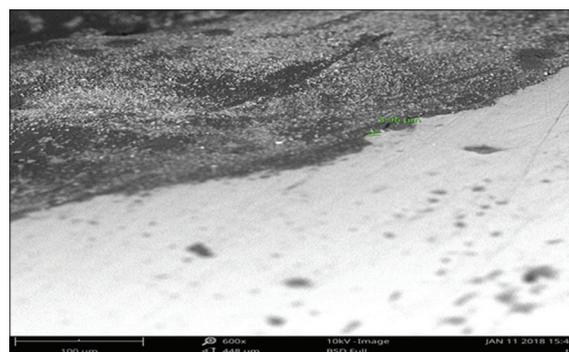


Figure 1: Scanning electron microscopy image of marginal discrepancy in Group A (Bond Plus SE)

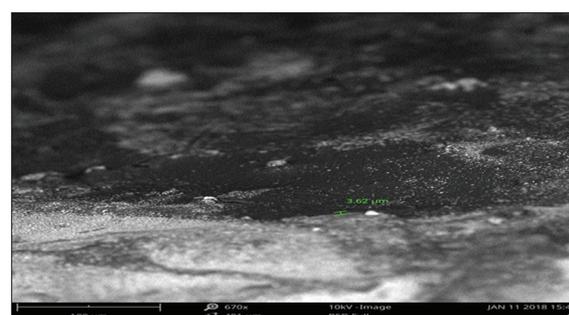


Figure 2: Scanning electron microscopy image of marginal discrepancy for Group B (Kerr OptiBond)

Placement of the Restoration

The adhesive system and their corresponding composites were applied by manufacturer's instruction. Since it is seventh, it does not require separate etching and rinsing procedures. After the application of the dentin bonding agent, the adhesive is cured with a halogen light curing unit. After the bonding procedure is done, the composite is added in two layers. The one layer was placed inside the cavity, and the layer was placed to fill the entire cavity, and the excess is removed. Each layer of composite is cured with the light curing unit. The restoration is finished and polished with polishing discs and pastes.

Assessment of MA

A high resolution scanning electron microscope ($\times 600$ magnifications) was used to assess the widest distance between the restoration and tooth structure in the cervical margins and the corresponding values were measured, the photographs were taken, and the results were tabulated [Figures 1 and 2].

RESULTS

Mean marginal discrepancy between tooth structure and the restoration in Group A was 3.35 ± 0.31 μm and for Group B was 3.67 ± 0.24 μm . An independent sample *t*-test was used to analyze the data. A statistically significant difference was observed between the two groups with $P < 0.05$ [Table 1].

DISCUSSION

Dental composite resins are types of synthetic resins which are used in dentistry as restorative material or adhesives. Synthetic resins evolved as restorative materials since they were insoluble, of good tooth-like appearance, insensitive to dehydration, easy to manipulate, and reasonably inexpensive. Composite resins are most commonly composed of Bis-GMA and other dimethacrylate monomers (TEGMA, UDMA, and HDDMA), a filler material such as silica and in most current applications, a photoinitiator. Dimethylglyoxime is also commonly added to achieve certain physical properties such as flowability. Further, tailoring of physical properties is achieved by formulating unique concentrations of each constituent.

As with other composite materials, a dental composite typically consists of a resin-based oligomer matrix, such as a bisphenol A-glycidyl methacrylate, urethane

dimethacrylate (UDMA), or ([semi-crystalline Polyceram]) (PEX), and an inorganic filler such as silicon dioxide (silica). Without a filler, the resin wears easily, exhibits high shrinkage and is exothermic. Compositions vary widely, with proprietary mixes of resins forming the matrix, as well as engineered filler glasses and glass ceramics. The filler gives the composite greater strength, wear resistance, decreased polymerization shrinkage, improved translucency, fluorescence and color, and a reduced exothermic reaction on polymerization. It also, however, causes the resin composite to become more brittle with an increased elastic modulus.^[7] Glass fillers are found in multiple different compositions allowing an improvement on the optical and mechanical properties of the material. Ceramic fillers include zirconia-silica and zirconium oxide.

A coupling agent such as silane is used to enhance the bond between these two components. An initiator package (such as camphorquinone, phenylpropanedione, or lucirin) begins the polymerization reaction of the resins when blue light is applied. Various additives can control the rate of reaction.

Resin filler can be made of glasses or ceramics. Glass fillers are usually made of crystalline silica, silicon dioxide, lithium/barium-aluminum glass, and borosilicate glass containing zinc/strontium/lithium. Ceramic fillers are made of zirconia-silica or zirconium oxide. Fillers can be further subdivided based on their particle size and shapes such as:

Micro filled fillers have a particle size ranging from 5 to 10 μm . They have good mechanical strength but poor wear resistance. The final restoration is difficult to polish adequately leaving rough surfaces, and therefore this type of resin is plaque retentive.

Microfilled fillers are made of colloidal silica with a particle size of 0.4 μm . Resin with this type of filler is easier to polish compared to macro filled. However, its mechanical properties are compromised as filler load is lower than in conventional (only 40–45% by weight). Therefore, it is contraindicated for load-bearing situations and has poor wear resistance.

Hybrid filler contains particles of various sizes with filler load of 75–85% by weight. It was designed to get the benefits of both macro filled and micro filled fillers. Resins with hybrid filler have reduced thermal

Table 1: Statistical analysis for difference between the means of two groups

7 th generation bonding agent	<i>n</i>	Mean	SD	SEM	<i>t</i> value	df	<i>P</i> value
Bond Plus (Group A)	20	3.3500	0.31164	0.09396	3.96	38	0.0003
Kerr OptiBond (Group B)	20	3.6773	0.23660	0.07134			

SD: Standard deviation, SEM: Standard error of the mean

expansion and higher mechanical strength. However, it has higher polymerization shrinkage due to a larger volume of diluent monomer which controls the viscosity of the resin.

Nanofilled composite has a filler molecule size of 20–70 nm. Nanoparticles shape nanocluster units and go about as a solitary unit. They have high mechanical strength similar to the hybrid material, high wear resistance, and are easily polished. Nanofilled composite resin is hard to adjust to the cavity edges because of the high volume of filler. Non-agglomerated discrete nanoparticles that are homogeneously distributed in resins or coatings to produce nanocomposites have been successfully manufactured by nanoproductions corporation. The nanofiller used: Aluminosilicate powder with a mean particle size of 80 nm 1:4 M ratio of alumina to silica and a refractive index of 1.508. These nanocomposites have superior hardness, flexural strength, modulus of elasticity, decreased polymerization shrinkage and also have excellent handling properties.^[21]

Bulk filler is composed of non-agglomerated silica and zirconia particles. It has nanohybrid particles and of 77% of filler content by weight. Designed to decrease clinical steps with the possibility of light curing through 4–5 mm incremental depth, and reduce stress within remaining tooth tissue. Unfortunately, it is not as strong in compression and has decreased wear resistance compared to conventional material.

Bonding agents are often methacrylates with some volatile carrier and solvent like acetone. They may also contain diluent monomers. For proper bonding of resin composite restorations, dentin should be conditioned with polyacrylic acids to remove the smear layer, created during mechanical treatment with the dental bore, and expose some of the collagen network or organic matrix of dentin. Adhesive resin should create the so-called hybrid layer (consisting of a collagen network exposed by etching and embedded in adhesive resin). This layer is an interface between dentin and adhesive resin and the final quality of dental restoration depends greatly on its properties. Modern dental bonding systems come as a “three-step system,” where the etchant, primer, and adhesive are applied sequentially; as a “two-step system,” where the etchant and the primer are combined for simultaneous application; and as a “one-step system,” where all the components should be premixed and applied in a single application (so-called seventh generation of bonding agents).

Seventh generation bonding agents are adhesives for bonding direct and indirect restorative materials to teeth have evolved through the years. Variations in the number of bottles and the mechanism of bonding have defined each “generation” of bonding systems. The 7th

generation combines the acid, primer, and resin in one bottle. These include only one step which eliminates the etching and rinsing procedure.

Mechanism of Action

Seventh generation bonding agents used the smear layer as a bonding substrate. The acidic primer demineralizes the smear layer and the top layer of the underlying dentin surface. The acidic primer likewise penetrates the uncovered collagen alongside the hydrophilic monomers, which at that point copolymerize. Because the etched surface is not rinsed, the demineralized smear layer is incorporated into the hybrid layer. The hybrid layer ranges in thickness from 0.5 μm to 5 μm . The acidic primer and adhesives also penetrate the collagen fibrils and primer decalcifies the inorganic segment in the dentin, which ought to limit voids, and post-operative sensitivity.

Ideal features of a 7th generation bonding agent are high bond strength (20–30 MPa) to enamel and dentin, thin film thickness to ensure complete seating of restorations, fluoride-releasing to prevent onset of secondary caries, resistant to moisture and dry environment, reduces post-operative sensitivity of tooth, available in light-cured and dual-cured formulations, and good shelf life.

Advantages include single step procedure, no mixing or rinsing procedure, reduced post-operative sensitivity of tooth, tolerant to moist and dry environments, and available in light-cured and dual-cured adhesives.

A good MA is very essential to increase the longevity of the composite resin restorations. Class V cavities were chosen in this study because they remain a challenge for restorative procedures. Thus, most of the clinical studies evaluating the performance of an adhesive system use Class V cavities. The C-factor of these cavities impairs the composite resin flowing during the polymerization shrinkage, increasing the stress over the bonding interface.^[22] Moreover, these cavities frequently present gingival margins in the dentin, consisting of an additional challenge to obtain a proper marginal sealing.^[23] In this study, the composite was added in incremental pattern and then cured.

In composite restorations, stress concentration on the restoration can lead to breakage of the bonding and lead to the gap formation. Hence, a proper bond of an adhesive system to the dental structure contributes to avoid marginal microleakage. In this present study, this adhesive system showed the best MA to the enamel margins than the other generation dentin bonding agents.

In this present study, this adhesive system showed the best MA to the enamel margins than the other generation dentin bonding agents. because of its substrate's

high mineral content. In contrast with the enamel, dentin is a more heterogeneous substrate, consisting of hydroxyapatite, collagen fibrils, and water. The acid etching of the dentin widens the opening of the dentinal tubules, exposes a layer of mineral-depleted collagen fibrils, and increases the water content.^[24] Self-etching adhesives with relatively high pH levels are unable to produce an acidic environment that will effectively etch the enamel.^[25] The presence of organic content and water leads to loss of proper bonding.

This current study shows that the more hydrophobic characteristic of this Bond Plus bonding agent contributes to form a more homogeneous and stable bonding than Kerr OptiBond. This explains the lowest gaps observed between the composite and the tooth structure when the Bond Plus was used, compared with the Kerr OptiBond. The other factors which influence bonding include the quality and health of the dentin, salivary and microbial contamination, depth of cure in the bonding agent and additional surface treatments of the underlying dentin. These factors should be meticulously control to minimize the marginal discrepancy between the tooth and the restoration to improve the clinical success.

CONCLUSION

Kerr OptiBond showed higher means of gaps than Bond Plus SE in the cervical margins. Even though a statically significance was observed between the two bonding agents, clinical significance may not be altered.

REFERENCES

- Gow AM, Hemmings KW. The treatment of localized anterior tooth wear with indirect artglass restorations at an increased occlusal vertical dimension. Results after two years. *Eur J Prosthodont Restor Dent* 2002;10:101-5.
- Kubo S, Kawasaki K, Yokota H, Hayashi Y. Five year clinical evaluation of two adhesive systems in noncarious cervical lesions. *J Dent* 2006;34:97-105.
- Peumans M, Kanumilli P, De Munck J, Van Landuyt K, Lambrechts P, Van Meerbeek B. Clinical effectiveness of contemporary adhesives: A systematic review of current clinical trials. *Dent Mater* 2005;21:864-81.
- van Dijken JW, Sunnegårdh-Grönberg K, Lindberg A. Clinical long-term retention of etch-and-rinse and self-etch adhesive systems in non-carious cervical lesions. A 13 years evaluation. *Dent Mater* 2007;23:1101-7.
- van Dijken JW, Pallesen U. Long-term dentin retention of etch-and-rinse and self-etch adhesives and a resin-modified glass ionomer cement in non-carious cervical lesions. *Dent Mater*.2008;24:915-22.
- Hilton TJ. Can modern restorative procedures and materials reliably seal cavities? *In vitro* investigations. Part 2. *Am J Dent* 2002;15:279-89.
- Braga RR, Ferracane JL. Alternatives in polymerization contraction stress management. *Crit Rev Oral Biol Med* 2004;15:176-84.
- De Munck J, Van Landuyt K, Peumans M, Poitevin A, Lambrechts P, Braem M, et al. A critical review of the durability of adhesion to tooth tissue: Methods and results. *J Dent Res* 2005;84:118-32.
- Irie M, Suzuki K, Watts DC. Marginal gap formation of light-activated restorative materials: Effects of immediate setting shrinkage and bond strength. *Dent Mater* 2002;18:203-10.
- Brackett MG, Tay FR, Brackett WW, Dib A, Dipp FA, Mai S, et al. *In vivo* chlorhexidine stabilization of hybrid layers of an acetone-based dentin adhesive. *Oper Dent* 2009;34:379-83.
- Bortolotto T, Ferrari I, Onisor I. Marginal adaptation of contemporary dentin bonding agents in enamel and dentin under the simulation of dentinal fluid. *Int Dent S Afr* 2005;5:21-6.
- Kemp-Scholte CM, Davidson CL. Marginal integrity related to bond strength and strain capacity of composite resin restorative systems. *J Prosthet Dent* 1990;64:658-64.
- Asmussen E, Peutzfeldt A. Class I and class II restorations of resin composite: An FE analysis of the influence of modulus of elasticity on stresses generated by occlusal loading. *Dent Mater* 2008;24:600-5.
- Ausiello P, Apicella A, Davidson CL. Effect of adhesive layer properties on stress distribution in composite restorations – a 3D finite element analysis. *Dent Mater* 2002;18:295-303.
- Kinomoto Y, Torii M. Photoelastic analysis of polymerization contraction stresses in resin composite restorations. *J Dent* 1998;26:165-71.
- Bowen RL. Adhesive bonding of various materials to hard tissues. VI. Forces developing in direct-filling materials during hardening. *J Am Dent Assoc* 1967;74:439-45.
- Kanca J 3rd, Suh BI. Pulse activation: Reducing resin-based composite contraction stresses at the enamel cavosurface margins. *Am J Dent* 1999;12:107-12.
- Kemp-Scholte CM, Davidson CL. Complete marginal seal of class V resin composite restorations effected by increased flexibility. *J Dent Res* 1990;69:1240-3.
- Braga RR, Hilton TJ, Ferracane JL. Contraction stress of flow able composite materials and their efficacy as stress-relieving layers. *J Am Dent Assoc* 2003;134:721-800.
- Papadogiannis D, Kakaboura A, Palaghias G, Eliades G. Setting characteristics and cavity adaptation of low-shrinking resin composites. *Dent Mater* 2009;25:1509-16.
- Sivaramakrishnan SM, Saveetha NP. Nanotechnology in dentistry-what does the future hold in store? *Dentistry* ;4:198.
- Kumar SS, Chacko Y, Lakshminarayanan L. Microleakage in posterior resin composite restoration using different filling, curing and polishing techniques. *J Conserv Dent* 2005;8:52.
- Santiago SL, Passos VF, Vieira AH, Navarro MF, Lauris JR, Franco EB. Two-year clinical performance of resinous restorative system in non-carious cervical lesions. *Braz Dent J* 2010;21:229-34.
- Silva e Souza MH Jr., Carneiro KG, Lobato MF, Silva e Souza PA, Góes MF. Adhesive systems: Important aspects related to their composition and clinical use. *J Appl Oral Sci* 2010;18:207-14.
- Ibrahim IM, Elkassas DW, Yousry MM. Effect of EDTA and phosphoric acid pretreatment on the bonding effectiveness of self-etch adhesive to ground enamel. *Eur J Dent* 2010;4:418-28.

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