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THE EFFECT OF AIR DRYING TIME ON BONDING (SELF ETCH) WITH ETHANOL AS A SOLVENT TO THE SHEAR BOND STRENGTH OF BIOACTIVE COMPOSITE RESIN

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ABSTRACT
Background: *Surface resistance between composite resin and dentin is currently one of the problems of restorative materials. Failure of composite resin are still being reported in clinical studies with failure rates ranging between 5-45% based on observations for 5-17 years. Bioactive composite resin is a new type of composite resin that has mechanical and chemical properties similiar to teeth. The use of resins, bonding materials, drying time of the solvent, and type of solvent also affect the shear bond strength* ***Purpose:*** *The purpose of this study was to analyze the effect of air drying time bonding (self-etch) with ethanol as a solvent on the shear bond strength of bioactive composite resins.* ***Methods:*** *This study used 32 non-carious maxillary premolar teeth that were fixed using acrylic resin. Fiber glass with a diameter of 3 mm and thickness of 3 mm were fixed to dentin surface and applied using bioactive composite resin were divided into 4 treatment group, i.e. the group without air drying, 20 s, 40 s, and 60 s. Shear bond strength test using Universal Testing Machine.* ***Results:*** *One Way Anova and Post Hoc Bonferroni test showed significant differences with p=0,002 (p<0,05). The average shear bond strength value of the lowest bioactive composite resin in the group bonding without air drying with a value of 6.381 ± 2.818 MPa and the highest shear bond strength value of the bioactive composite resin in the 60 seconds bonding air drying group with a value of 11.873 ± 2.931 MPa.* ***Conclusion:*** *The air drying time of the bonding affects the shear bond strength of the bioactive composite resin.*

Keywords: *Air drying time, bioactive composite resin, bonding, ethanol, shear bond strength.*
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INTRODUCTION

Composite resin is one of the most frequently used by dentists because it has several advantages, including having good aesthetics, easily manipulated, have the same color as teeth, and insoluble in oral fluids.[1] Bioactive composite resin is the latest type of composite resin introduced in 2013. The filler material contained in bioactive composite resin almost the same chemical and physical properties as teeth.[2] As time goes by, composite resin an experience failures which are shown to reach 5-45% based on observations for 5-17 years. This failure can be caused by fractures and degradation that occur in the oral cavity which can change the structure of the polymer matrix and filler particles in composite resin.[3] Retention of composite resins as a tooth lift material can be improved by the use of etching and bonding techniques.[4]

Bonding is the process of attaching two different surfaces, between the tooth structure and the restoration material. The use of bonding plays a role in adhesion of composite resins to the hard tissue structure of the tooth, to improve the quality of composite resin as a restoration material.[5] In the recent technological advancements, bonding has evolved from no etching to total-etch (4th generation and 5th generation), then evolved again into self-etch (6th, 7th, and 8th generation). There are three bonding techniques, namely etch and rinse, self-etch and resin modified glass ionomer approach.[6] In 2011, a new type of bonding was introduced, namely universal bonding, known as

multifunctional bonding which can be used from etch and rinse and self-etch. The factors that affect the strength of the bonding are the type of bonding material, the duration of air drying, tooth surface treatment, and how to apply the bonding material.[6] Bonding contains hydrophilic and hydrophobic monomers, which have the main differences, namely the chemical properties of each monomer and solvent.[6] The addition of a solvent can increase the spread and penetration of monomers into the dentine substrate. Materials used as solvents are ethanol, acetone, and water.[7]

The most commonly used solvent bonding is alcohol. Hydrogen bond causes alcohol to be very hygroscopic, it will absorb water and oxygen.[5] Ethanol is one of the alcohols that is often used as a solvent but evaporates slowly and requires sufficient time for drying.[6] Ethanol has a higher vapor pressure than water, making it easier in removing water from demineralized dentin after resin infiltration.[8] According to Reis and Loguercio, ethanol based solvent have greater retention in non-caries cervical lesions after 36 months of treatment, compared to those acetone solvents. The bonding solvent material after being applied will evaporate due to the air drying. Air drying will remove the solvent from the primer, and the presence of air can inhibit polymerization.[8] Infiltration of the bonding material and removal of the solvent can be achieved by extending the application duration of the bonding material on the dentin surface.[9]

Optimal resin infiltration is an important factor in the formation of a good bonds, the bond between resin and dentin can be formed if the primary material and resin are able to penetrate through the smear layer and interact with the dentin surface.[9] If the solvent has not been completely disappeared then it will reduce the bonding strength of the bonding material. The high concentrations of solvents contained in self-etch can inhibit polymerization of monomers to demineralized tooth substrates. Imperfect polymerization will create high permeability in the bonding layer and reduce the mechanical properties of the polymers in the hybrid layer.[10] Prasetyo's research (2018), stated that the use of bonding with ethanol based solvent can affect the shear bond strength of composite resin.[11]

Shear bond strength is the maximum resistance of the material to hold the load until the lift is released when it is shifted, for example, withstand the chewing load during mastication. The shear bond strength test is performed to measure the strength of bonding as an adhesive material between enamel or dentin with a composite resin, using a universal testing machine.[3] Factors that affecting the shear bond strength are the process of preparation and restoration of dental samples. The use of resin, bonding material, the drying time of the solvent, type of solvent, how to dry the solvent also affect the shear bond strength.[12,13]

The surface resistance between composite resin and dentin is currently one of the problems of composite resin restorative materials. Research efforts to increase bond strength of bonding to dentin and reduce degradation have been undertaken, but still far from expectations. The bioactive effect of composite resins containing Bioactive Glass can last longer and a better hybrid coating stability.[14] Bonding and bioactive materials are a good mixture because they are beneficial for the patient's teeth, especially those which is associated with high risk of caries.[15] The duration of bonding material application is one factor that determines the strength of bonding. The application of bonding material on dentin surfaces generally takes around 20 seconds.[16] The results of research conducted by Fu (2017) stated that the strength of a bonding depends on the material and the duration of air drying. Bonding with a drying time of 15 to 30 seconds has greater bonding strength.[17]

Based on the description above, there has been no research on the effect of bonding drying time (self-etch) with ethanol as a solvent on the shear strength of bioactive composite resins. Therefore, researchers are interested in conducting research on the effect of bonding drying time (self-etch) with ethanol as a solvent on the shear strength of bioactive composite resin.

MATERIALS AND METHODS

This study has been through ethical eligibility approval by the Health Research Ethics Commission No. 057 / KEPKG - FKGULM / EC / I / 2020 publised by the Faculty of Dentistry, Lambung Mangkurat University. This study was a true experimental study with a posttest only with control group design. This study used 32 non-carious maxillary premolars that uses simple random sampling consisting of 4 treatment groups (8 samples for each group). Sample preparation using the light curing unit (Woodpeker) with intensity 800 mW / cm^2 (USA), plastic filling instrument, stopwatch, incubator, PVC cylinder, niebeken, microbrush, threeway syringe, contra angle handpiece, micromotor low speed, fissure bur, carborundum disc, stellon pot, cement spatula, silicon carbide #600 grit, glass plate, glass beaker, tweezers, markers, labels, digital scales and Universal Testing Machine. The materials used in this study were maxillary premolar teeth less than 6 months according to ISO / TS 11405: 2015, bioactive composite resin (ACTIVA™ Bioactive

Restorative), artificial saliva with a pH of 6.7, bonding material (Single Bond Universal Adhesive), and acrylic resin.

Fiber glass mold for composite resin overlays with lengths of 20 mm, widths of 20 mm, and height of 3 mm. The internal diameter of 3 mm and a thickness of 3 mm according to ISO / TS 11405: 2003. The most extensive middle buccal premolar is prepared as deep as 2 mm. Make acrylic resin as a dental fixation. Prepare cylindrical PVC molds as a place for fixation sample. The mold is placed on the glass plate as a base. Liquid and catalyst are mixed in a stelon pot and stirred using a cement spatula, then poured into a cylindrical mold until it full. The tooth samples were placed on cylindrical mold, waited until the acrylic resin hardened to fix the teeth. Dentin surfaces were ground with 600-gritt sandpaper for 60 seconds to obtain a standardized smear layer. The application of bonding material with ethanol as a solvent on the dentin surface using a microbrush on a digital scale with 3 grams pressure. The treatment groups i.e. group 1 without air drying, group 2 air drying for 20 seconds, group 3 air drying for 40 seconds, and group 4 air drying for 60 seconds. The dentin surface was dried with a three-way syringe according to each drying time and light-cured for 10 seconds. Bioactive composite resin was applied using a plastic filling instrument and placed on the sample mold.

Bioactive composite resin was cured using LED light curing unit with 800 mW/cm^2 intensity for 20 seconds. The sample from each group was taken using tweezers and immerse in an artificial saliva solution in an incubator at 37ºC for 24 hours. Samples that have been finished soaking, according to the specified time are taken using tweezers and placed on a nierbeken then put a label that has been written with a marker on 4 nierbeken according to each treatment. The shear bond strength test using a Universal Testing Machine with a load of 50 kgF and crosshead speed of 0.5 mm/min until the specimen fractured. The result then calculated with the formula SBS = F/A to obtain shear bond strength with A = πr^2. The data were evaluated statistically by conducting Shapiro-Wilk tests and Levene's test. Parametric analysis using the One Way ANOVA hypothesis test with a confidence level of 95% ($\alpha = 0.05$) and continued with the Post Hoc-Bonferroni test. Data processing is processed using SPSS computer software.

RESULTS

The result of the shear bond strength test of bioactive composite resin obtained the average values presented in table 1.

Table 1. Mean and Deviation Standards of Shear Bond Strength of Bioactive Composite Resins

Group	The value of Shear Bond Strength (MPa) Mean ± Deviation Standard
Group 1	6.381 ± 2.818
Group 2	7.141 ± 2.060
Group 3	10.513 ± 3.829
Group 4	11.873 ± 2.931

Based on table 1, it can be seen that the average shear bond strength value of the lowest bioactive composite resin is in the group without air drying bonding with a value of 6.381 ± 2.818 MPa and the highest shear bond strength value of the bioactive composite resin is in the 60 seconds air drying bonding group with a value of 11.873 ± 2.931 MPa.

The Shapiro-Wilk normality test in all groups is ($p > 0.05$) which means data is normally distributed. Homogeneity test using the Levene's test $p = 0.554$ ($p > 0.05$) which means the data is homogeneous. One Way Anova and Post Hoc Bonferroni test showed significant differences with $p=0.002$ ($p<0.05$).

Table 2. Post Hoc Bonfferoni Test Table of Shear Bond Strength of Bioactive Composite Resins

Group	1	2	3	4
1	-	1.000	0.058	0.006*
2	-	-	0.188	0.022*
3	-	-	-	1.000
4	-	-	-	-

*p <0.05

Based on table 2, it is known that the Post Hoc Bonfferoni test results showed that there were significant differences ($p < 0.05$) between the groups without air drying bonding with 60 seconds air drying bonding and the groups 20 seconds air drying bonding with 60 seconds air drying bonding. It can be concluded that the air drying time of the bonding affects the shear bond strength of the bioactive composite resin.

DISCUSSION

The results of this study showed that there were significant differences between the groups without air drying bonding compared to 60 seconds air drying time bonding and 20 seconds air drying bonding group compared to 60 seconds air drying bonding group. This because the length of contact between the bonding material and the surface of the tooth will have an effect because if it is the less contact time it cannot bind free radicals.[5] Air drying in the self-etch system applied to the dentin surface generally that has a significant effect on the bond strength.[17]

Based on the results of this study, it is showed that the lowest average of shear bond strength was found in the group without air drying bonding. This is because the remaining water and solvents have not been completely lost, it can interfere with polymerization of the adhesive monomer, reduce the quality of the hybrid layer, and can reduce the bond strength.[17] This is according to Chiba et al (2006) research which states that the treatment without air drying bonding has the low bonding strength because without air drying, solvents such as ethanol can act as inhibitors for polymerizing the resin components in the adhesive.

The results showed the group with 60 seconds air drying bonding had the highest average shear bond strength. Air drying on bonding can provide better solvent evaporation and only leaves the priming resin on the surface of the dentin, it produced a higher degree of conversion.[18] All solvents must be completely removed from the adhesive prior to the light activation. Therefore, prolonged time are needed for the solvent to carry out its function then evaporates and ensures the properties of the appropriate adhesive layer.[19] In a research of Werle et al (2015) stated that 60 seconds of air drying bonding shows a better bond strength. Prolonged air drying can evaporate the solvent better and can reduce adhesive damage to the surface. Prolonged air drying can provide more time for monomer diffusion, which leading to a better interaction between acid monomers and substrates. The study also said that bond strength could be increased by extending the air drying time.[20]

The bonding material contains hydrophilic, hydropobic monomers and solvents.[6] The main function of solvent is to carry the monomer into the dentine substrate. By reducing the viscosity of the monomer, the solvent can provide better wetting and penetration into the dentine. The solvent present in the adhesive acts like a transporter medium and lower viscosity of the resin in the adhesive solution, allowing the resin monomer to penetrate into the demineralized porous surface of the dentin.[18] The solvent can move the water in the dentin when the monomer enters the demineralized dentin. The physical properties of solvents such as solubility parameters, vapor pressure, and hydrogen bonding capacities affect bonding of dentin. Ethanol has a better hydrogen-bonding capacity.[21]

Ethanol is one of the solvents found in the bonding that is used in this study. Ethanol has a higher vapor pressure than water, which making it easier to remove water in demineralized dentin after resin infiltration and helps in reducing nanoleakage in the hybrid layer.[8] Ethanol has a stiffening effect on demineralized collagen thus maintain interfibrillar space in collagen tissue.[22] Ethanol has a low surface pressure and easily spreads on the surface so that it can help the filtration of resin monomers, and ethanol can reduce the diameter of the fibrils of the collagen matrix thereby increasing attachment by forming more hybrid layers than the water use.[23] Ethanol based solvents can evaporate in 5 minutes. In this research, within 60 seconds ethanol was able to evaporate.[24]

Solvent evaporation on bonding should be maximized and the adhesive layer must be dried with air to ensure adequate evaporation of the solvent.[25] Air drying can remove the solvent on the surface of the dentin. The higher the solvent content in the polymer, the lower the mechanical properties and strength of the resin-dentin bond. Adequate bonding of adhesive material to dentin depends not only on adequate penetration into the dentine, but also on the mechanical properties of the adhesive.[26]

A strong air blowing generated from a threeway shringe can reduce the bond strength due to the thin layer of the adhesive. In this study, the air pressure used was 0.25 MPa, which is considered to be an average air blowing pressure that is not gentle or strong.[27] Evaporation of adequate solvents through the air drying for a long time will produce a better bond. Although the high conversion rate shows an increase in the working power of the mechanism adhesive layer, the micromechanical interlocking process of the polymerization process of the adhesion system against exposed collagen fibers is also an important parameter in the bonding capacity of dentin in the long term. Therefore, both the magnitude of the monomer conversion and the accuracy of the application and how the binding material in the dentin polymer matrix adjusts to the mechanical work conditions of the material to increase the resistance of the restoration.[19]

The bioactive composite resin used in this study contains Bioactive Glass which lasts longer

and has good hybrid layer stability.[14] The bioactive composite resin does not contain Bisphenol-A and Bis-GMA thereby minimizing shrinkage. Bioactive composite resins can release fluorine ions, phosphate ions, and calcium ions which affect the pH changes in the oral cavity. This reaction can improve the mechanical properties, surface resistance, protection against fractures, and protection from marginal leakage.[28] Bioactive composite resin have the advantage of being more resistant to pressure and have antibacterial properties. The material contained in the bioactive composite resin has mechanical and chemical properties similiar to the teeth. [29]

To determine the strength of adhesion between the restoration material with the tooth surface, it is necessary to test the adhesive resistance of the composite resin, one of which is the shear bond strength test. The shear bond strength test is a test conducted to measure the bonding strength as an adhesive material between enamel and dentin with a composite resin as seen or loss attachment that occur at the interface area between the tooth structure and bonding material.[30] The shear bond strength test is using Universal Testing Machine.[3] From the results of this study, it showed that the highest shear bond strength value was found in the group with 60 seconds air drying bonding with a value of 11.873 MPa. These results are similiar with the research of Werle et al (2015) which showed that with 60 seconds air drying bonding, the shear bond strength value is 11.28 MPa. The research results of Argolo et al (2012) also said that with 60 seconds air drying bonding, the highest shear strength value was 12.0 MPa.

The value of shear strength of this study is comparable to the study of Braga et al (2010) which showed that the average value of shear bond strength in self-etch systems is around 5-12 MPa. Unlike the total etch system the value of shear bond strength is around 17-25 MPa.[31] Although the value of bond strength in the self-etch system is not as high as in the total etch system, the self-etch system offers simpler application techniques and reduces the work time, and has the main function of reducing postoperative sensitivity.[32] Resin-based material is inseparable from the contraction pressure. Composite resin can withstand contraction pressures with a minimum bond strength of around 17-20 MPa in enamel and dentin. In clinical use, the value of the bond strength can be a better parameter of successful composite resin retention. A contraction pressure that is greater than the attachment strength can cause damage to the bonding of the material with the tooth structure to which it is attached.[33] The harder a surface is, the higher the surface energy, which means high adhesive properties.[31] At the interface area, the stronger the bond the stronger the attachment.[34] Based on the results of this study it can be concluded that there is an influence of the air drying time bonding (self-etch) on the shear bond strength of the bioactive composite resin.

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