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THE EFFECT OF BAGASSE FIBER (*Saccharum officinarum L.)* ADDITION ON THE COMPRESSIVE STRENGTH OF BULK FILL COMPOSITE RESIN

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ABSTRACT

Background: *Bulk fill composite resin is a composite resin with 4 mm filling technique in one application and lighting in one time. This material commonly used for posterior teeth restoration, so good compressive strength is needed. The increase in compressive strength in restoration can be used with addition of synthetic fiber or natural fiber. Natural fiber that can be used is bagasse fiber.* ***Purpose:*** *To acknowladge the influence of bagasse fiber addition to the compressive strength of bulk fill composite resin.* ***Methode:*** *This study was a true experimental study with posttest only control group design. The total of the sample was 24 samples that were divided into 3 groups, which consisted of: group 1 bulk fill composite resin with addition of bagasse fiber, group 2 bulk fill composite resin with addition of synthetic fiber and group 3 bulk fill composite resin without addition of fiber. The measurement of compressive strength used universal testing machine.* ***Result:*** *The average value of compressive strength of group 1 was 353,466 MPa, group 2 was 364,583 MPa and group 3 was 348,698 MPa. The result of parametric One Way ANOVA test was p=0,000 (p<0,05) and continued with Post Hoc Bonferroni test showed that there was significant difference between each groups (p<0,05).* ***Conclusion:*** *The addition of bagasse fiber influence the compressive strength of bulk fill composite resin higher than those without the addition of bagasse fiber, but it is still lower if compared with the addition of synthetic fiber.*

Keywords: *Bulk fill composite resin, bagasse fiber, compressive strength*

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INTRODUCTION

Composite resin is a restoration material used to restore functional and tissues of anterior or posterior damaged tooth.[1,2] Resin composites contained resin matrix, filler, coupling agent, initiator activator and other additional components such as inhibitor and modifier optics in small quantities.[3] Restoration using composite resin requires a long processing time and shrinkage can happen after the polymerization process.[1] Improvements for composite resin are continuously made in terms of application techniques and its content to obtain better outcomes.[4]

In 2010 composite resin was developed with bulk fill technique. Application of bulk fill composite resin into the cavity is capable of reaching a depth of 4 mm in one application and uses one time lighting.[5] The other advantages are reducing the risk of porous buildup, minimal microleakage and high elasticity.[6] The composite resin undergoes several modifications on the initiator and matrix components.[5] The monomers in the matrix form longer bonds with closer monomer, resulting in smaller shrinkage.[7] The color in stability becomes the deficiency of this material.[8] The mechanical properties of bulk fill composite resins depend on the composition of each material, but generally the mechanical properties are poorer than conventional composites.[9]

The use of bulk fill composite resin is generally for posterior tooth restoration.[5] High mastication pressure on the posterior tooth should be considered for the mechanical properties of the material used, one of which is the compressive strength. The compressive strength is tested by providing pressure to determine the durability of the material. The low compressive strength value of the composite resin will increase the risk of fracture.[2] Efforts to increase the mechanical properties of the material can be accomplished by adding a fiber layer into the composite resin.[4]

The fiber commonly used in the field of dentistry to strengthen restoration is synthetic fiber. Synthetic fibers are available in a wide range, such as aramid fiber, carbon fiber, glass fiber and polyethylene fiber.[10] The components of synthetic fiber consist of silica fibers which are 7-10 µm in diameter, biocompatible, good aesthetics, no corrosion, high modulus elasticity and a more even distributed mastication pressure.[4] The deficiency of these synthetic fibers is the high price, so the use of natural fibers such as bagasse fibers can be used as fiber reinforced composite.[11]

Sugarcane (*Saccharum officinarum L.*) is a family of Gramineae (grasses) produced by many people to be processed into sugar. Sugarcane plantations in Indonesia are widespread as the increasing of sugar sales in the market. This is due to the increasing population every year.[12,13] The processed sugarcane produces 90% bagasse waste, whereas sugarcane juice is produced only about 5% and the remaining 5% molasses. The lack of waste management of bagasse by sugar producers causes the percentage of waste to increase.[14] The bagasse has 43-52% fibers with the main components of lignocellulosic compounds consisted of 50% cellulose, 25% hemicellulose and 25% lignin.[15,16] Bagasse has a diameter of 20 µm along the 1,7-2 mm.[17] Fiber bagasse is not susceptible to fungi, resistant when stored in a humid environment, has adequate strength and more economical in price.[14,15,18] The purpose of this study is to determine the effect of fiber bagasse (*Saccharum officinarum L.*) on compressive strength of bulk fill composite resin.

MATERIALS AND METHODS

This study used true experimental method with post-test only control group design. Sample preparation and compressive strength testing were done at the Laboratory of Materials Engineering Department of Mechanical and Industrial Engineering, Gadjah Mada University. The number of samples was determined using unpaired numerical analytic formula.[19] The total sample in this study was 24 samples and divided into 3 groups, so that in each group consisted of 8 samples.

The research began with the processing of bagasse fiber. The sugarcane plant used was sugarcane plant that was ready to be harvested. The sugarcane was processed through the 5 times milling process with the help of the machine to obtain the bagasse. The bagasse was washed and then soaked for 1 day to dissolve the contained sugar substance. Next, the bagasse was cleaned from corks attached to the fiber by combing it using a wire brush, then dried for 1 day under the sun. After the drying process, bagasse was combed again to remove any cork remnants that still attached. Each fibers of bagasse were taken by hand.

The bulk fill composite resin was given 3 different treatments, where group 1 was given the addition of bagasse fiber, group 2 was given the addition of synthetic fiber and group 3 without the addition of fiber. The sculptable composite resin is inserted into a 4 mm thick mold using a filling instrument, then pressed to compress the composite resin using a condenser and lighted for 20 seconds at a distance of 1 mm. After the first layer hardened apply primer using microbrush. The 2 mm thick sculptable composite resin was applied over the first layer, then small amount of flowable composite resin was applied. The bagasse fibers and synthetic fiber were cut along 3 mm and primer was dropped on the glass plate. Next, the fibers were then placed on a flowable composite resin. The fiber was covered by sculptable composite resin to fill the sample mold. The composite resin was flattened with the mylar strip and lighted again. The preparation of group 3 stage is the same as group 1 and group 2, but did not use flowable composite resin and no fiber was added.

The composite resin sample was removed from the mold and inserted into a plastic container with saline solution, then stored in an incubator for 24 hours at 37^0C and a compressive strength test was performed. Testing of sample compressive strength using universal testing machine with speed of 0,5 mm/min with 500 kgf load. Pressure was applied from the top surface of the sample and the pressure was stopped after the sample fractured. The maximum force numbers listed on the monitor screen were observed and then put into a compressive strength formula, which is:[20]

$$CS = \frac{F \times 9{,}807}{\pi r^2}$$

Note :

CS = Value of the compressive strength (MPa)

F = Maximum force value recorded at monitor screen (kgf)

9,807 = Value of gravity

r = Sample radius (mm)

π = 3,14

RESULT

The result data of compressive strength test of bulk fill composite resin which was given the addition of bagasse fiber, synthetic fiber and without addition of any fiber as seen in table 1.

Table 1. Table of mean and standard deviation of bulk fill composite resins compressive strength on each group

Group	Mean ± Standard Deviation (MPa)
Group 1	353,466 ± 3,018
Group 2	364,583 ± 2,930
Group 3	348,698 ± 1,543

Note:
Group 1: Bulk fill composite resin with addition of bagasse fiber
Group 2: Bulk fill composite resin with addition of synthetic fiber
Group 3: Bulk fill composite resin without any addition of fiber

Based on table 1, it is shown that the bulk fill composite resin group with the addition of synthetic fiber has the highest mean value of compressive strength compared to other groups. Normality test using Shapiro-Wilk test resulted in group 1 p=0,682 (p>0,05), group 2 p=0,216 (p>0,05) and group 3 p=0,396 (p>0,05). The homogeneity test using Levene's test showed p=0,132 (p>0,05). Normality and homogeneity test results showed that all data were normally distributed and homogenous, so that statistical analysis test continued using One Way ANOVA parametric test. One way ANOVA parametric test results obtained p=0,000 (p<0,05), which means there were significant differences between groups. The analysis data was continued with the Post Hoc Bonferroni test and the results can be seen in table 2.

Table 2. Result of post hoc bonferroni test on compressive strength of bulk fill composite resin

Group	1	2	3
1	-	0,000*	0,004*
2	0,000*	-	0,000*
3	0,004*	0,000*	-

*= There is significant difference (p<0,05)
Note:
Group 1: Bulk fill composite resin with addition of bagasse fiber
Group 2: Bulk fill composite resin with addition of synthetic fiber
Group 3: Bulk fill composite resin without any addition of fiber

Based on table 2, it is shown that the results of the Post Hoc Bonferroni test in group 1 with group 3 p=0,004 (p<0,05), group 1 with group 2 and group 2 with group 3 p=0,000 (p<0,05), which means there were significant differences in all groups.

DISCUSSION

The results showed that the addition of fiber for strengthen the bulk fill resin composite can increase the compressive strength value. This is in accordance with Wahyuni et al (2013) study which states that the highest mean value of compressive strength is shown in composite resin with addition of a fiber.[21] Treatment groups with fibers fracture during compressive strength test, but the fractures remain gathered in one. In contrast, the results in the group without addition of fiber shown that the samples fractured into pieces. These results are similar to those of Mozartha et al (2010) who did a test in flexural strength. The study states that the addition of fiber layers in composite resins can inhibit the fracture to occur when receiving pressure. The fracture will stop at the fiber layer, so the composite resin will not split into two parts or experience brittle fracture as in the composite resin without any addition of fibers.[22]

Factors affecting the strength of fiber reinforced composite resins are fiber position and fiber direction.[23] Placement of fibers in exact position and direction will increases the resistance and mechanical properties of composite resins. The fibers on the sides closer to the top surface of the sample is the side that receives the compression load, so the fiber will affect the compressive strength of the restoration.[23,24] Fiber placed in the horizontal direction or the load given is perpendicular to the fibers which will result in a stronger restoration, compared to fibers in a vertical or parallel to load direction.[25] The fiber in this study is placed on the compression side in a horizontal direction, so that the compressive strength of the bulk fill composite resin increases.

The bulk fill composite resin with added bagasse fiber has a lower mean value of compressive strength than with synthetic fibers and shows a significant difference. This may be due to lack of attachment between the fibers and the resin matrix. The resin should evenly cover the entire surface of the fibers to have stronger bond. Application of adhesive materials will help the fibers to stick with the resin matrix, so the pressure from the composite resin can be spread evenly to the fibers. Fiber that is not covered perfectly can lead to the formation of an empty gap which will affect the mechanical strength as well as the lack of resistance from fracture in the composite resin.[25,26] Another factor that inhibit the increase of strength in composite resin with added fiber is the diameter of the fiber and the amount of fiber used.[27] The bagasse fiber has larger diameter than the synthetic fibers, which are 20 µm for bagasse fiber and 7-10 µm for synthetic fiber. The usage of smaller fiber diameters will increase the amount of fiber used for the composite resin.[28,29,30] More fibers used will give the ability for the fiber to absorb more pressure, there by increase the resin composite resistance to fracture.[24]

Bulk fill composite resin in this study used 1 layer of fiber. A research by Wahyuni et al (2013), shows composite resin with 2 layers of fiber has a higher compressive strength than composite resin with 1 layer fiber.[21] The same research results also shown in the study of Nabilah et al (2016), which states that composite resin with addition of 3 layers fiber has highest flexural strength than the addition of 1 layer fiber or 2 layers fiber. This indicates the number of layers of fiber on the composite resin affecting the resulting strength. The pressure on the first fiber layer will be channeled to the further fiber layers evenly, there by providing high strength for the restoration.[24,26]

The use of synthetic fibers in bulk fill composite resins produce the highest average value of compressive strength. This research used synthetic fiber type impregnated e-glass fiber with unidirectional fiber structure. Unidirectional glass fiber is twice as flexible and stronger than polyethylene fiber.[32] Impregnation is a process of wetting fiber using a polymer matrix to help create a good adhesion between fibers with resin matrix.[24,32] A research by Gundogdu et al (2014) with the use of impregnated glass fiber produces greater strength compared to non-impregnated polyethylene fiber.[32]

The mechanical and chemical properties of synthetic fibers are determined from the content of the fibers.[33] The e-glass fibers in this study contain about 45,47% SiO_2, 38,49% CaO, 12,11% Al_2O_3 and 0,94% K_2O.[35] Generally, e-glass fiber consists of 54,5% SiO_2, 17% CaO, 14,5% Al_2O_3, 4,5% MgO and less than 2% of Na_2O and K_2O.[35] Silica oxide (SiO_2) is the main constituent in glass fiber with the highest percentage that has the ability to react with the matrix. The small amount of silica oxide on glass fiber will lead to changes in the structure of the fiber. Calcium oxide (CaO) and magnesium oxide (MgO) are the alkaline earth metal oxide content which can increase the fiber strength. The addition of CaO, MgO and Al_2O_3 function to provide fiber resistance toward any chemical material.[33,34,36] The components with the smallest percentage in glass fibers are metal oxides Na_2O and K_2O which give a waterproof effect and prevention for corrosion. The high amount of Na_2O and K_2O cause the components of the fiber to decompose, due to process of alkali hydrolysis.[33,34] These components produce good mechanical properties and chemical properties in e-glass fibers, such as tensile strength and high compressive strength, resistant from chemical, high temperature and moist.[33,37]

The indoor lighting needs to be noted during the process of sample making, the technique of inserting composite resins and oxygen. The composite resin exposed to the light when removed from the tube may result in free radical reactions in the composite resin. This causes composite resins to undergo early polymerization. The technique for inserting the composite resin into the sample mold needs to be awared in order to avoid air getting trapped in composite resins. The use of sharp-pointed instruments when applying composite resins can lead to formation of empty gap when the next layer is inserted.[38] Oxygen in the gap can inhibit the polymerization reaction, since oxygen binds free radicals and form peroxide radicals. This bond creates free monomers on the surface of a composite resin which is called the oxygen inhibited layer. Free monomers will remain after polymerization, since the reactivity of free radicals with oxygen is higher than the free radicals with monomers.[39] The presence of oxygen inhibited layers can reduce hardness, resistance of wearness and marginal adaptation of composite resins.[40]

This study has some deficiencies, such as the difference in bagasse fiber diameter. The diameter of the fiber will determine the strength result. The smaller the diameters of the fiber will result in greater strength.[41] The researcher's limited ability to applicate the fiber into the sample mold and the composite resin is not covered evenly, resulted in an empty gap between the fibers and the composite resins which can reduce the increase in strength of the composite resin.[25]

Based on the results of the research, it can be concluded that the addition of bagasse fiber (*Saccharum officinarum L.*) has an effect on the compressive strength of bulk fill composite resin and shows higher value than without addition of fiber, but still lower when compared with synthetic fiber.

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