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RESEARCH ARTICLE

The transversal strength comparison between polyethylene and glass fiber as an acrylic resin denture plate repair material

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ABSTRACT

Acrylic resin is the most commonly used denture base material. However, it has a shortage of being easily broken. One way to resolve this problem is by adding polyethylene (PE) or glass fibers. The purpose of this research is to compare the transversal strength of PE and glass fibers from denture plate acrylic resin repair material. The experiment involved 32 plates of heat cure acrylic with the dimensions of 65 mm x 10 mm x 2.5 mm. The speciments were prepared to create a 3 mm gap and 45° bevel. Subjects were divided into 2 groups, each group containing 16 plates. Group I was reinforced with PE fiber and Group II was reinforced with glass fiber. All plates were soaked in distillation water for one day at 37 °C. Plates were tested for transverse strength with universal testing machine and all data were analyzed with independent t-tes at 95% confidence level. Macro photo analysis was used to observed the bond failure on fiber and resin. The mean of transverse strength (MPa) denture plate acrylic resin repair material reinforced with PE fiber was (67.38 ± 4.31) MPa, while glass fiber was (93.61 ± 6.14) MPa. Independent t-tes showed that type of fiber had a significant effect ($p<0.05$). Thus, it is possible to conclude that addition of glass fibers in denture plate acrylic resin repair material increased the transverse strength and made it stronger than those added with PE fibers.

Keywords: acrylic resin repair material; glass fiber; polyethylene fiber; transverse strength

INTRODUCTION

The number of denture users in 2007 in Indonesia reached 4.5% of the population and most of users are the residents aged over 65 years old. The most widely used denture is the type of removable denture.[1] Acrylic resin is still the most preferable material in making denture plates because it is affordable, easy to repair, easy to process, only requires simple equipment, and has a stable color and is easily polished.[2] However, problems frequently found in removable denture made of acrylic resin is a fracture or cracks of the denture plate caused by a large occlusal pressure.[3]

Several attempts to increase the strength of acrylic resin denture plate repairs have been made, such as by modifying denture plate material or by adding fiber.[4] The use of fiber in acrylic resins has been widely developed. This is because fiber has some characteristics including the ability to improve the physical and mechanical properties of acrylic resin, the ability to increase the strength of acrylic resin plates, the shape of the fiber that is easy to use, being easy to regulate, and having good aesthetic properties.[5]

Polyethylene (PE) fiber is made from spun gel fiber with very high crystallinity of around 95% -99%.[6] Cold glass plasma in PE can increase reactivity and wetting ability of the fiber so that it can produce chemical and physical interactions.[7] Glass fiber is a reinforcing fiber that is most frequently used. The advantage of glass fiber lies on its strength, transparency, and affordability.[8] Glass fiber materials with unidirectional structure have strength and flexibility twice as strong as PE materials, but glass fiber has unfavourable stiffness and often shows cracks on the surface.[9] Each fiber material has advantages and disadvantages, so it is necessary to concern on the physical properties of

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fiber material added to the denture plate including fiber type and fiber/matrix ratio. Determination of the exact physical properties of fiber in acrylic resins produce better strength on acrylic resin denture plates.[10]

Transverse test is a simulation of the pressure distribution received by denture plates in the oral cavity. High transversal strength is required by a material to withstand mastication pressure which can result in permanent deformation.[11] This research aims to determine the comparison of transversal strength between PE and glass fiber as reparation material for acrylic resin denture plates.

MATERIALS AND METHODS

This study has received ethical clearance from the dental health research ethics Faculty of Dentistry Universitas Gadjah Mada number 00306 / KKEP / FKG-UGM / EC / 2015. The acrylic sample was made in a rectangular shape with the size of 65 mm x 10 mm x 2.5 mm with a modified cavity in the middle measuring 30 mm x 5 mm x 2 mm made of red wax with a shape according to the sample. It was planted in a cuvette containing a plaster cast dough. After the cast hardens, it was smeared with Vaseline and made as a counter model. The cuvette was then boiled to remove the red wax model to form a mould chamber. The formed mould and counter model were smeared with CMS to prevent the resin from sticking to the cast. Acrylic monomers and polymer resins were mixed in stellon pots in a ratio according to factory requirements, which is 23 grams of polymer and 10 ml of monomers. Acrylic resin dough was put into the mould after reaching the dough phase. The cuvette was pressed to make a metal to metal contact and left for 1 hour for better dimensional stability.[12]

The cuvette and press were processed in water at 70 °C for 90 minutes, and then the temperature was raised to 100 °C for 30 minutes. After the process was complete, the cuvette was left until it reached a room temperature. Acrylic resin plates were taken and smoothed with sandpaper numbers 300, 600, and 1000 then measured with a sliding caliper. Each test rod was divided into two of equal lengths and marked with a pencil. The test rod was cut using a carborundum disc and made a distance of 3 mm at the edge of the preparation (each of the test rod that had been cut to 2 was reduced by 1.5 mm at the edge of the preparation). The edges of the preparation were made at a 45° tilt angle to increase repair retention. Test rods that were ready to be connected were placed into a prepared mould measuring 65 mm x 10 mm x 2.5 mm.

The 32 research subjects were divided into 2 groups, each group consisting of 16 acrylic resin test rods. For group I, hot polymerization acrylic resin plates were repaired by placing PE in the mold preparation followed by the application of new acrylic resin (heat polymerization). For group II, hot polymerization acrylic resin plates were repaired by placing glass fiber in the mold preparation followed by the application of new acrylic resin (heat polymerization).

The hot polymerization acrylic resin dough was made with a ratio between monomers and polymers of 1 cc: 2.3 g. The entire surface of the fiber was smeared with monomer liquid. Prior to the placement of group I acrylic resin dough, PE material was given into the mould preparation. Acrylic resin dough which had reached the dough phase was placed in the preparation mould, and the counter model was closed and pressed. The cuvette and press were boiled in 100 °C water for 45 minutes, after which the water was waited to cool at a room temperature then the repaired test rods were taken to tidy up its excesses, and polished. Prior to the the placement of acrylic resin dough of Group II, a sheet of glass fiber that had been coated with silane by the factory was added into the mold preparation. Acrylic resin dough which had reached the dough phase was placed in the preparation mould, and then the counter model was closed and pressed. The cuvette and press were boiled in 100 °C water for 45 minutes, after which it was waited until the water has cooled to room temperature. Then, the repaired test rods were taken to tidy up its excesses and polished. Before the mechanical strength test was carried out, the sample was stored in an incubator by immersing it in aquadest at 37 °C for 24 hours. This immersion aims to obtain the same conditions as the oral conditions and equilibrium water sorption.[12] Transverse strength testing was performed with a universal testing machine.

RESULTS

The research was started with preparing a sample in the dental technology laboratory of the Faculty of Dentistry UGM followed by testing the transversal strength of the research sample in the material laboratory of mechanical and industrial engineering at the Faculty of Engineering, UGM. Measurement of the transversal strength of acrylic resin denture plates shows that acrylic resin denture plates that are repaired with the addition of glass fiber posess higher transversal strength than PE (Table 1).

The normality test of the transversal strength data were performed by Shapiro-Wilk. Normality test revealed a statistical value of 0.877 with a significance of p = 0.257. It is possible to conclude that the data are normally distributed. Homogeneity test was carried out using the Levene`s Test. Homogeneity test showed a statistical value of 2.909 with a significance of p = 0.067 which means that the data were homogeneous. T test was used to determine differences in fibre types. The results of the t calculation for fibre type variables were 1,746 which was significant ($p<0.05$). It indicated that the different types of fibres have a significant influence on the transversal strength of acrylic resin denture repair. Acrylic resin denture plate repairs reinforced with the addition of glass fiber produce higher transversal strength compared addition of PE.

Table 1. Average and standard deviation of transversal strength (MPa) of resin fibre reinforced with different types of denture reparation

Groups	Number	Average ± standard deviation
Acrylic reinforced with PE	16	67.38 ± 4.31
Acrylic reinforced with glass fiber	16	93.61 ± 6.14

Figure 1. Macro fracture photos on a test bar with the addition of PE. Fracture occurs both on resin and bonding PE to resin acrylic

Figure 2. Macro fracture photos on the test rod with the addition of e-glass fiber. Fracture occurs only on resin acrylic.

DISCUSSION

Table 1 presents that glass fibre has a higher transversal strength than PE. This is possibly due to the presence of metal oxide content in E-glass fibre and metal oxides like SiO[2] that function like fillers in fibre systems. The filler content in a material system can increase the mechanical strength of a material, one of which is transversal strength.[11] This reinforces the reason that glass fiber produces higher transversal strength than PE. Based on statistical analysis, fiber types differ significantly where glass-type fibers produce higher transversal strength in acrylic resin plate repairs. To improve adhesion, this research was conducted to review the monomer liquid on the fiber surface. Fiber wetting can increase the strength of reinforced fibers and adhesion of polymers to fibers. Impregnation of monomeric liquid in PE with a woven structure is worse than in glass fiber with unidirectional structure so that the mechanical strength in PE with a woven structure is also lower. Macro photographic images in the PE sample show that the fracture on the test rod occurs in the bond between fiber and acrylic resin (Figure 1), whereas Figure 2 shows that the test rod fracture in the glass fiber sample occurs in the entire resin structure without involving the damage to the bond between e-glass fiber and acrylic resin. In good impregnation of the monomeric liquid on the surface of the fiber, it is possible to reduce the transversal strength that appears by transmitting the force to the entire surface of the resin matrix properly.[13]

Modification of the surface of the fiber using silane such as found in glass fiber can increase the adhesion between the fiber and the polymer that may increase the mechanical strength of the reinforced fiber. Glass fiber with silane as a coupling agent prevents the gap between the polymer and fibers thus reducing the possibility of water absorption by the resin.[13] The use of silane coupling agent causes the glass fiber to bind to the acrylic resin matrix. Silane has a hydroxy group that can be attracted into the hydroxy group on the surface of the glass fiber. The organo-functional group reacts with the resin matrix and forms strong bonds. Silane can bind to polymethyl methacrylate resin. Silane is hydrolyzed into silanol and forms covalent bonds in the CH_2 methyl methacrylate group. Silanol can form covalent bonds with resin polymer chains and form organic groups.[14]

An acrylic resin material as a denture plate in the oral cavity must possess the transversal strength of at least 60-65 MPa,[11] the addition of fiber in the repair of acrylic resin plates can be selected. Strength that is higher than the minimum standard acrylic resin plate is needed because the bite strength in human anterior teeth can reach 132.748 MPa, whereas in posterior teeth it reaches 237.169 Mpa.[15] Thus, it is necessary to determine the type of reinforcing material for acrylic resin plate repair to increase the mechanical strength of the resin plate acrylic.

CONCLUSION

Acrylic resin denture plate repairs with glass fiber increase transversal strength higher than polyethylene (PE) fiber.

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