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Original article

The effect of giomer's preheating on fluoride release

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ABSTRACT

Background: *Secondary caries occur due to imperfect plaque control. Prolong the protective and therapeutic effects can be done with restorative materials that release fluoride. Now composite resins have been developed a new restorative hybrid material with new matrix component, namely giomer. Giomer composition containing surface pre reacted glass ionomer (S-PRG) as a major source of fluoride production. Increasing the mechanical strength and minimize microleakage to prevent secondary caries can be done with preheating treatment.* ***Purpose:*** *This study is conducted to determine the effect of preheating temperature on the release of giomer's fluoride.* ***Methods:*** *This study used 9 cylindrical samples in 10 mm diameter and 2 mm thickness each group, divided into 3 groups and 3 subgroups. Group 1: preheating at 37°C for 30 minutes. Group 2: preheating at 60°C for 30 minutes. Group 3: as a control group (without preheating treatment). Each group divided into 3 subgroups immersion, on day 1, day 7 and day 14 with artificial saliva. Fluoride release test was conducted by Spectrophotometer. IBM's SPSS Statistics used for the Data analysis.* ***Results:*** *The addition of preheating treatment decrease the amount of fluoride release. One-way ANOVA test showed a significant difference ($P < 0.05$). A significant difference between groups and sub groups showed in LSD test ($P < 0.05$).* ***Conclusion:*** *The group without preheating treatment has highest fluoride release and the 60°C preheating treatment group was the lowest. Addition of preheating treatment may increase the mechanical strength and minimize microleakage, but also descrease the amount of fluoride release.*

Keywords: *fluoride release; giomer; preheating*

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INTRODUCTION

Secondary caries are the outcome of unsuccessful plaque control. The location of secondary caries usually occurs at the margin of the filling, and is most common on the gingival margin in class II to V fillings, and is rarely seen in class I restorations.[1] Restorative materials that release fluoride could prolong the protective or therapeutic effect on tooth enamel, especially in areas prone to secondary caries.[2]

Composite resin is a restorative material that is widely used for enamel abrasion, caries restoration, as well as for aesthetic needs, because it has a good fit with teeth.[3] Composite resin consists of three main components, namely matrix, filler, and coupling agent. Composite resin matrix generally contains Bis-GMA, this matrix content is classified as conventional composite resin. The composite resin matrix is composed of monomers that have double-chain carbon bonds and have distances between the monomers.[4] The disadvantage of composite resin is the shrinkage during polymerization (polymerization shrinkage), which can cause the formation of micro-leakages or gaps between the tooth surface and the composite resin.[4]

Now composite resins have been developed a new restorative hybrid material with new matrix component, namely giomer.[5] Giomer is a new hybrid restorative material with a composition containing a derivative of glass ionomer cement called filler S-PRG. Surface Pre Reacted Glass Ionomer (S-PRG) filler can release and recharge fluoride.[2] Restorative materials that release fluoride allow to extend the therapeutic effect or protection to the tooth enamel, especially in the approximal area that is contacted with the material. Because the proximal area is an area with high plaque accumulation, it may be a cause for the formation of lesions of white dots when the surface is in contact with other surfaces with carious lesions.[2]

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Saliva as a natural protective factor could prevent or inhibit caries formation, because of Ca^{2+} and HPO_4^{2-} ion can replace the lost ions in the teeth, but if the pH in saliva is 5.5, which is a bad condition for hydroxyapatite, it will cause demineralization. Giomer can reduce the risk of hydroxyapatite and fluorapatite's breakdown. The acid neutralizing ion in the oral cavity released by giomer is strontium ion ($Sr2^+$).[5] Surface hardness can also be affected by pH in the oral cavity; according to research, there was an increase in hardness at a higher pH, about 125% after immersing giomer in artificial saliva pH 4.5 increased to 7.13±0.01 after soaking for 72 hours.[5]

Preheating the composite resin before irradiation can reduce the occurrence of micro leakages and make it easier for application and manipulation.[6] Preheating is a method of heating the composite resin prior to irradiation. Preheating can be done using a composite warmer or a conventional oven.[7] Preheating treatment can make the composite resin stronger, reduce viscosity so as to facilitate the adaptation and application of composite resin to the cavity, and can improve its mechanical properties.[8,9]

Research on the giomer surface microhardness in previous studies, shows that preheating treatment at 60°C has a higher hardness than 37°C.[10] Another previous research, showed that preheating treatment at 60°C could lead to decreased microleakage and better marginal adaptation to composite resins.[11] Based on previous research that provides preheating treatment so as to increase mechanical strength and minimize microleakage in composites, it encourages researchers to conduct research that has never been done before to determine the effect of preheating treatment temperature on the release of giomer's fluoride.

MATERIALS AND METHODS

Ethical approval which is managed as a condition for conducting research has been obtained from the Research Ethics Commission of the Faculty of Medicine, Jenderal Soedirman University (No. 005.KEPK.01.2021). This research is an experimental laboratory with a post-test only control group design. The data used primary data which were directly collected by the researcher.

Figure 1. Cylindrical sample.

The bulkfill giomer Beautifil II from Shofu.Inc was used as a research sample for all groups and sub-groups. Nine samples in each group were used in the study. This study divided these into three groups: preheating at 37°C group (group A), preheating at 60°C group (group B), and a control group without preheating treatment (group C). Each group was divided into three sub-groups, immersion with artificial saliva on day 1, day 7 and day 14. Each group and sub-group consisted of cylindrical samples with a diameter of 10 mm and a thickness of 2 mm.[12]

Preheating was done using a conventional oven. Sample mold was using a square shaped acrylic having a cylindrical hole in the center with diameter of 10 mm and height of 2 mm as a place to put the sample. The sample mold was given a prep glass which had been given Vaseline previously using a microbrush.

Samples were molded after preheating treatment for each group to the mold. Sample was condensed using cement stopper and coated with a celluloid strip. After that covered with another prep glass and then pressed gently so that the sample surface was flat.

The sample was light cured for 20 seconds. After the sample was polimerized it was separate from the mold and polished using a rubber bur until the surface was smooth. All samples were immersed in 20 ml of artificial saliva solution in sterile bottles according to groups and subgroups. The immersion water of each group was collected on days 1, 7, and 14 to be tested for fluoride release. The sample test of fluoride release was carried out using a spectrophotometer (Spectroquant Pharo 300).

Table 1. The result of giomer's fluoride release

Group	Day 1	Day 7	Day 14
A (37°C)	0.87	0.81	0.71
B (60°C)	0.76	0.71	0.63
C (Control)	1.03	0.91	0.72

Table 2. One-way ANOVA test results for the release of giomer's fluoride

Group	Mean (ppm)	Standard deviation	Sig
A (37°C)	0.79	0.04	
B (60°C)	0.70	0.05	0.000*
C (Control)	0.88	0.04	

Note: * = Significant difference ($p<0.05$).

Table 3. Results of LSD further test for the release of giomer's fluoride

Group	A (37°C)	B (60°C)	C (Control)
A (37°C)		0.001*	0.002*
B (60°C)	0.001*		0.000*
C (Control)	0.002*	0.000*	

Note: * = Significant difference ($p<0.05$)

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RESULTS

The test results are in the form of fluoride release data in ppm units. The results of the study on the effect of preheating on the release of giomer's fluoride in direct restorations used a cylindrical sample measuring 10 mm x 2 mm. The results of the fluorine ion release test results are presented in Table 1.

Data analysis was performed using IBM's SPSS Statistics version 20. Data were found to be distributed normally (P>0.05) and homogeneous (P>0.05). ANOVA test was then performed and a significant difference was found between the treatment groups (P<0.05) (Table 2). The data were further tested for significant differences between treatments groups and sub-group using the LSD, and there were significant differences between treatments groups and sub-group (P<0.05) (Table 3).

DISCUSSION

Giomer is one of the restorative materials in dentistry that is capable of releasing fluoride.[7] Giomer has unique properties in the form of components that distinguish it from other composites, namely S-PRG, which is coated with an ionomer layer within the resin matrix, and allows for the protection of the glass core from moisture, providing long-term aesthetics and durability of conventional composites with ion release and recharge.[14] S-PRG in giomer is contained in the resin matrix as a filler.[14] S-PRG filler can release and recharge fluoride, and can release five other ions such as sodium, strontium, aluminum, silicate, and borate. These ions have an important role in neutralizing the acidic state when exposed to lactic acid produced by bacteria in plaque. Acid neutralization minimizes the possibility of secondary caries and makes restorations more durable.[2]

The advantage of using a fluoride-releasing restorative material is to protect the restored tooth surface during exposure to cariogenic agents, and has been widely studied with good results.[15] Previous research showed that a 13-year-follow-up of in vitro study found a 66% retention rate and the secondary caries rate of only 3.27% with giomer-based restorative material. The research showed that giomer has a high amount of fluoride release and has the ability to be recharged, along with physical properties that could rival other composite system.[14]

Preheating could lead to increase the degree of conversion, because polimerization involving free radicals will change the viscosity from high to low viscosity. This process will convert the C=C double bond into a covalent C–C single bond between the methacrylate monomers, which causes a change in the rate of free radical diffusion.[16] The activation of free radicals is also influenced by high light intensity, so that more monomers will be converted. The degree of polymerization is also influenced by the mobility of free radicals and monomers so that polymer cross-links occur. Polymer cross-links can form covalent bonds resulting from polymers adjacent to electrons. These cross-links act as a reaction bridge between linear macromolecules to form 3-dimensional working bonds that can change the strength, solubility, and water sorption of the composite resin, which could produce a material that is stronger than polymers that have single chains.[9,17] Additional polymerization can be carried out by adding preheating treatment to the composite resin before irradiation.[17]

The advantages of preheating treatment include a stronger composite resin, reducing viscosity, making it easier to manipulate and adapt the composite resin to cavities, reducing microleakage and increasing mechanical properties such as hardness, diametral tensile strength and compressive strength.[8,9] The decrease of fluoride release pattern along with increased temperature is influenced by several factors, namely temperature, water sorption and giomer's polymerization.[16] The preheating treatment carried out in this study caused the carbon double chains breaking into single chains of the resin polymer contained in the giomer sample. The single polymer chain in the resin makes the polymer able to react with the monomer more evenly.[16]

The temperature increase of the giomer can cause a decrease in the rate of diffusion, which causes a delay in the rate of diffusion, reduced porosity and decreased surface roughness, and the opportunity for the S-PRG filler to contact with water is also reduced, which results in a decrease of the amount of fluoride released.[7,18] As seen in the sample group preheating treatment at 60°C (Group A) on giomer showed the lowest fluoride ion release, with an average of 0.69 ppm and the group without preheating treatment (Group C) had the highest fluoride ion release, with an average of 0.88 ppm.

The polymerization phase in composite resins affects the quantity of fluoride release caused by segmental mobility of the polymer chain, so that when the preheating temperature is higher, the segmental polymer chains increases, and brings on more complete polimerization, which causes a decrease in fluoride release.[19] In this study, it was seen that the quantity of fluoride ion released at 37°C (Group A) had a higher average yield (0.79 ppm) than 60°C preheating. This is due to the lower degree of conversion at preheating temperature of 37°C which resulted in the final result of sample polymerization being less perfect when compared to preheating temperature of 60°C, which had more perfect polymerization.[16] The average yield of fluoride ion release in the control group was higher (0.88 ppm) compared to the other treatment groups because, in the control group, giomer did not get a higher temperature change. The polymerization chain segmental formed on the composite without the treatment of higher temperature changes will be more so that it makes the surface have more gaps, and this causes the release of fluoride to increase.[16]

The results of fluoride release between groups that have been carried out in this study showed that the fluoride

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release decreased along the increasing immersion time. This decreasing pattern of ion release is caused by the fluoride that has been liberated between the polymer chains; the amount will decrease if there is no intake or exposure to fluoride from the outside.[20]

In normal conditions of the oral cavity where individuals can seek fluoride exposure into the body (from food, drink, or additional supplements), then the amount of fluoride can be stable because the giomer is able to retake and release fluoride. However, in this study, artificial saliva that was not treated with added fluoride was used as the immersion medium, so that the amount of fluoride released would decrease over time. The number of ions released by the giomer is influenced by the amount of water absorbed and the porosity of the giomer. Giomer's low fluoride release caused by the limited fluoride content of the giomer filler, low water content, low solubility of ytterbium trifluoride in water, and permeability of the resin composite which causes the fluoride released to also decrease over time.[19]

The release of fluoride is less in artificial saliva, due to the possibility of calcium ions in the saliva immersion medium and the formation of CaF_2.[21] The immersion medium containing water also affects the release of fluorine ions in the giomer. In this study, the largest ion release occurred on the first day of immersion in each group, with an average result of group A of 0.87 ppm, group B of 0.76 ppm, and group C of 1.03. There was a greater release of ions on the first day of immersion, and in the first week to the fourth week there was no significant difference or had started to stagnate. The release of fluoride can occur due to mediation by the ability of the material to diffuse water.[19]

The absorption of liquid from resin-based materials occurs due to a combination of adsorption and absorption. Adsorption can be seen from the ability of liquid molecules to reach the surface of a solid material. Absorption involves the penetration of a liquid molecule into a solid structure primarily by diffusion. Diffusion that occurs in resin-based restorations is a controlled diffusion process, and the most water absorption occurs in the matrix resin. Giomer's S-PRG filler technology means the surface of the resin matrix containing S-PRG reacts with polyacrylic acid during contact with water to form a thick silica hydrogel layer.[19]

The ion release mechanism occurs when the surface of the giomer which has gone through the light-curing process is in contact with water. Silica gel is a material that is stable to high temperatures.[22] The S-PRG in contact with water then dissolves the ions that are not bound in the polymerization chain formed in the light cured giomer. The polymer contained in the giomer will react when given a light from the light cure to form a polymer chain. Among the polymer chains, there are several ions that are not involved in the polymer chain so that they can dissolve in the immersion medium. Ions that are not involved in this polymer chain include fluoride, calcium and aluminum.[19]

Addition of preheating treatment may increase the mechanical strength and minimize microleakage, but the addition of preheating treatment also decreases the amount of fluoride release. To increase the mechanical strength and minimize microleakage, along with amount of fluoride release, according to this study, the best preheating temperature that can be used is 37°C. Addition of preheating treatment may increase the mechanical strength and minimize microleakage, but also decreases the amount of fluoride release.

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