

Differences of Composite Resin Surface Hardness After Exposure to Filter Cigarette and Electric Cigarette Smoke

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ABSTRACT

Background: Composite resin is a dental filling material that has several mechanical properties, one of which is surface hardness. Surface hardness can increase due to several factors such as smoking habits. Filter cigarette is the second most common type of cigarette in Indonesia and electric cigarette is the third most common type of cigarette in Indonesia. Both types of cigarettes can affect the surface hardness of the composite resin due to a decrease in the pH of saliva produced from cigarette smoke. **Objective:** This study aimed to determine the difference in surface hardness of the composite resin after exposure to filter cigarette smoke and electric cigarette. **Methods:** 27 samples of nanohybrid composite resin were divided into three groups. Group 1 as a control group was immersed in artificial saliva and was not exposed to cigarette smoke, group 2 was the group that was treated with filter cigarette smoke and group 3 was the group that was treated with electric cigarette. Furthermore, the groups were tested for surface hardness using a Vickers hardness tester. **Results:** The surface hardness test of the composite resin showed an increase in the control group and a decrease in the treatment group, with the highest decrease in the filter cigarette smoke treatment group. The results of the paired t-test and one-way ANOVA test showed that the p-value was >0.00 so there was no difference between the pre-test and post-test mean differences in each group and there was no difference between the mean of each group. **Conclusion:** There was no difference before and after exposure to filter cigarette or electric cigarette smoke.

Keywords: Composite Resin Surface Hardness, Electric cigarette, Filter Cigarettes.

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INTRODUCTION

Smoking is still a big problem in Indonesia. According to Riskesdas, the prevalence of smokers increased by 28,8%.¹ there are innovations from conventional smoke, called electric cigarette. Filter cigarettes contain tobacco, nicotine, and TAR which are harmful to both passive and active smokers. Therefore, electric cigarette were created which are claimed to be harmless because of the "HEALTH" label on the packaging.² However, according to Food and Drug Administration (FDA) research in 2009, there are diethylene glycol (DEG) and tobacco nitrosamines (TSNA) are toxic and carcinogenic.³ Electric cigarette are cigarettes in the form of an Electronic Nicotine Delivery System (ENDS), which do not burn tobacco, but the liquid is burned using a battery and the smoke enters the user's lungs.²

Composite resin is a material that is insoluble, insensitive to dehydration, has good aesthetics, and is easy to manipulate.⁴ In the composite resin, there is a bioactive composite that can release phosphate ions, calcium ions, and fluorine ions at an acidic pH which will reduce the activity of protease enzymes as collagen degraders.⁵ Composite resin has four main compositions, namely matrix, filler, coupling agent, and inhibitor.⁶ There are four types of composite resin based on the filler that are macrofilled composite (20-30 μ m), microfilled composite (0.01-0.1 μ m and 5-50 μ m), hybrid composite (0.01-0.1 μ m), and nanofilled composite (1-100nm). The smaller the particle size of the composite filler, the less the microfissure color, polymerization shrinkage, and changes.⁷

According to Mustakim,⁸ regarding the recency of similar research using acrylic artificial tooth samples, there is a significant change in the color of acrylic artificial teeth after exposure to filter cigarette smoke. The color of acrylic artificial teeth also changed after exposure to electric cigarette smoke, but not significantly. The purpose of this research was to find out and analyze the difference in the level of hardness of

the composite resin after being exposed to filter and electric cigarette smoke. Based on the background of the problem, the focus of this research included changes in the hardness of composite resins after exposure to filter and electric cigarettes, scientific articles that can add scientific references in the field of Dentistry, and information material about the level of danger of filter cigarettes and electric cigarette.

This study aimed to determine and analyze differences in the level of hardness of composite resins after exposure to filter and electric cigarette smoke. The benefits and potential of the research carried out are to provide scientific contributions, especially in the scope of dentistry regarding differences in the surface hardness of composite resins after exposure to filter and electric cigarette smoke, as well as information material for the development of other research with similar topics.

MATERIALS AND METHODS

This research begins with the manufacture of a test object in the form of a composite resin which is molded using a metal ring mold with a diameter of 12 mm and a thickness of 2 mm. The specimens used in this study were 27 samples which were divided into 3 groups, group 1 as a control group that was immersed in artificial saliva and not exposed to cigarette smoke, group 2 as a group treated with filtered cigarette smoke and group 3 as a group treated with smoke electric cigarette.

The sample will be placed in a smoking simulation tool made using a jar for each treatment group, then a hole is made according to the diameter of the cigarette on the lid of the jar. On the left or right side of the jar, a hole is made for inserting the hose and cotton. At the bottom of the jar, a hole is made to insert a catheter syringe that has been separated from the needle. Prior to sample treatment, all samples were immersed in artificial saliva for 24 hours to adjust to the conditions of the oral cavity. The soaked samples, were then stabilized at room temperature for 24 hours. Furthermore,

hardness values were measured before being exposed to filters and e-cigarette smoke using the Micro Vickers Hardness Tester. Measurement of hardness value using a ratio scale with hardness unit measured by Vickers Hardness Number (VHN).

All samples that have been tested for hardness are divided into 3 groups. Group 1 samples were immersed in artificial saliva for 24 hours in 21 days placed in a closed container and the artificial saliva was replaced every day. Groups 2 and 3 samples were arranged in a fumigation simulation tool using red wax so that the composite resin was stable and the position of the composite resin was facing the tip of the cigarette. Composite resin samples that have been well fixed in a smoking simulation tool can be exposed to cigarette smoke.

Exposure to filtered cigarette smoke begins by inserting the tip of the smoked cigarette into the jar to the smoking limit marked by a line circling the cigarette. The tip of the cigarette that is outside the jar is burned using a lighter. The plunger of the syringe is pulled and pushed slowly so that the filter cigarette burns out. After the filter cigarette is completely burned, the plunger of the syringe is pulled slowly as if it were smoking cigarette smoke so that the cigarette smoke can enter the jar in about 3-5 seconds in one puff. Furthermore, the cigarette smoke in the jar is removed by pushing the plunger slowly as if exhaling cigarette smoke from the mouth. The plunger is pulled and pushed until one cigarette runs out which is indicated by the cigarette dying by itself at the smoking limit. After 30 minutes, the cycle is repeated on another cigarette. The number of filter cigarettes smoked in a day is six cigarettes because the average chronic smoker smokes six cigarettes in one day. After all cycles were completed, the samples were immersed in distilled water for 1 minute, then immersed in artificial saliva for 24 hours. After that, the cycle was repeated for 21 days. After all cycles were completed, the samples were immersed in distilled water for 1 minute, then immersed in artificial saliva for 24 hours. After that, the cycle

was repeated for 21 days.

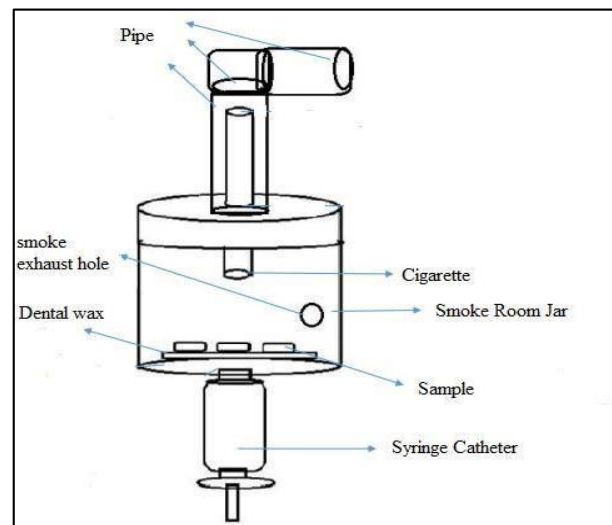


Figure 1. Design of a smoking simulation tool.⁸

Exposure to filter cigarette smoke is done by inserting the tip of the cartridge that is being smoked into a jar. Exposure to smoke is done by gently pulling the plunger of the syringe as if it were smoking cigarette smoke so that cigarette smoke can enter the jar in about 3-5 seconds in one puff. After the cigarette smoke in the jar is removed by pushing the plunger slowly as if blowing cigarette smoke out of the mouth. Pull and push the plunger of the syringe for 3 minutes. After 30 minutes, the cycle was repeated six times. After all cycles were completed, the samples were immersed in distilled water for 1 minute, then immersed in artificial saliva for 24 hours. After that, the cycle was repeated for 21 days.

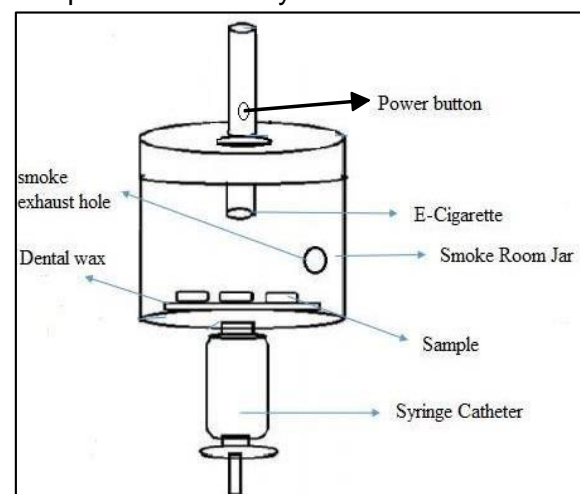


Figure 2. Design of a smoking simulation tool.⁸

After 21 days, all groups were tested for hardness using the Micro Vickers Hardness Tester at the UGM Materials Laboratory. Furthermore, the change in the surface hardness of the composite resin was calculated from the difference between the initial and final hardness measurements. The calculation results are recorded in the Vickers Hardness Number (VHN). The data was processed using the SPSS computer program. Furthermore, the data obtained from the 3 groups were tested for normality and homogeneity. If the data is normally distributed and homogeneous, then the One Way ANOVA parametric test is performed. If the data is not normally distributed, then it is continued with the Kruskal Wallis non-parametric test.

RESULTS

A total of 27 composite resin samples were treated differently in each group, which were group 1 as a control group immersed in artificial saliva, group 2 as a group exposed to filter cigarette smoke, and group 3 as a group exposed to electric cigarette smoke. Each group consists of 9 samples. then the sample was tested for sample hardness using a Vickers hardness tester. The results of the sample hardness test were obtained from three measurements on each sample and then the average hardness test results were taken for each sample so that the following results were obtained:

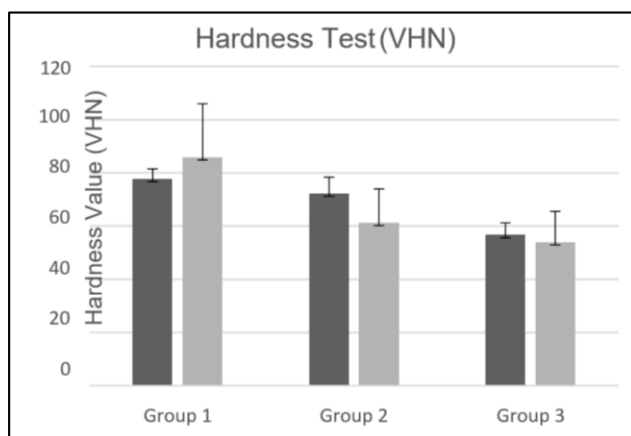


Figure 3. Graph of pretest and posttest results

The test results showed the average value of the surface hardness of the composite resin in each group produced different results. The average composite surface hardness of group 1 increased by 8.03 VHN, group 2 decreased by 11.09 VHN, and group 3 decreased by 2.69 VHN. The average surface hardness of the composites that experienced an increase was in group 1 which was not exposed to cigarette smoke. The average composite surface hardness that experienced the highest decrease was in group 2 exposed to filter cigarette smoke, and the lowest decrease was in group 3 exposed to electric cigarette smoke. The difference in the average surface hardness of the composite before and after treatment was described in the following figure:

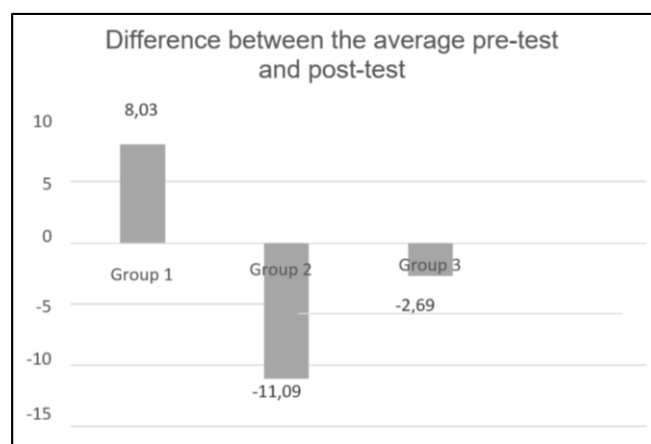


Figure 4. Graph of the average difference between pretest and posttest

The data was then analyzed using Statistical Product and Service Solutions (SPSS) software. The data analysis stage begins with a normality test carried out using Shapiro Wilk because the number of samples is 21 which means less than 50 and the homogeneity test was carried out using the Levene Test. The results show that the data in each group have a $p > 0.05$, which means that the data were normally distributed and homogeneous. Furthermore, a parametric test in the form of a paired t-test was carried out to determine the difference in the average sample before and after treatment in each group, so that the following results were obtained:

Table 1. The results of the Paired Test

No	Group	Average (VHN \pm SB)		P-value
		Pretest	Posttest	
1	1	77,77 \pm 3,74	85,80 \pm 20,16	0,266
2	2	72,20 \pm 6,21	61,12 \pm 12,87	0,071
3	3	56,61 \pm 4,57	53,92 \pm 11,60	0,501

The results of the paired t-test of groups 1, 2, and 3 before and after treatment showed a p-value of more than 0.05, meaning that H0 was accepted and H1 was rejected, where there was no significant difference in the surface hardness of the composite resin, both pretest and posttest in the group. 1, 2, and 3. Then a one-way ANOVA test was conducted to find out whether there were significant differences in each variable, the following results were obtained:

Tabel 2. The results of *One-Way ANOVA*

No	Group	Number of samples	P-value		P value
			Average	SB	
1	1	9	18,77	9,03	0,117
2	2	9	14,28	12,82	
3	3	9	8,52	7,54	

In Table 2. the p-value results were more than 0.05. It meant that H0 was accepted and H1 was rejected so that it can be stated that all variables do not have significant differences.

DISCUSSION

Composite resin is known as one of the materials used for dental restorations. Composite resin has several physical properties, namely polymerization shrinkage, solubility, and air absorption, as well as mechanical properties consisting of flexural strength, modulus of elasticity, roughness, and surface hardness.⁷ Almost all of these composite properties can change after exposure to various substances, both natural and, one of which is exposure to cigarette smoke.

The occurrence of an increase in surface hardness in group 1 in connection with research

conducted by Langen, et al.,⁹ which showed that a number of nanohybrid composite resins immersed in saliva improved the surface quality. This occurs because of a buffer function in saliva which functions to withstand the rise and fall of pH in the oral cavity.¹⁰ The bicarbonate anhydrase enzyme in saliva can catalyze the reaction between free H⁺ ions from bicarbonate ions to produce distilled water and carbon dioxide which will be released into the oral cavity. This causes the salivary pH to slowly return to its normal pH in approximately 30-60 minutes.⁹ Another study conducted by Fitriyana,¹¹ also stated that artificial saliva had an effect in increasing the compressive strength of type II glass ionomer cement soaked in isotonic drinks.¹¹ This is because saliva has a buffering function in the oral cavity and is also self-cleaning for both teeth and dental restorative materials, such as composite resins.

Meanwhile, the decrease in the surface hardness of the composite resin in groups 2 and 3 occurred due to the pH produced by filter cigarette smoke being lower than that of electric cigarettes. The pH of filter cigarette smoke is 6.4 with a range of 5-8, and the pH of electric cigarette smoke is 6.8 with a range of 5-7. This is related to the research conducted by Somayaji, et al.,¹² that composite resins immersed in different acid beverages decreased the hardness of nanohybrid composite resins after 21 days and showed that the lower the pH, the greater the decrease in hardness. These acidic conditions cause a lot of H⁺ ions to be released from their hydroxyl groups that can attack the double bonds of the polymer matrix composite which can cause broken instability. The breaking of the polymer double chain chemical bonds based on the composite resin causes degradation of the composite resin composite which can reduce the surface of the composite resin. The released H⁺ ions can also attack the siloxane as a bond that connects the matrix and filler particles so that it can cause filler particles and composite matrix.^{13,14,15}

Apart from the decrease in pH, a decrease in the hardness of the composite resin

can occur due to the hydrolysis process produced by the heat from cigarette smoke. The heat of cigarette smoke can increase the kinetic energy of air diffusion so that it can increase the absorption of air in the resin composite. The absorbed air will undergo a hydrolysis process so that the air decomposes into H^+ and OH^- due to the presence of O elements in the resin matrix. OH^- ions from water can enter the matrix and attack the siloxane (Si-O-Si), which is a link between the matrix and filler particles, so that the siloxane is cut off and silanol compounds (Si-OH) and Si-O are formed. Si-O can react when it meets air because it experiences electron disorientation. The reaction produces Si-OH and OH^- . OH^- breaks the siloxane again and the cycle continues as long as the composite resin is immersed in air. The longer the cycle occurs, the higher the risk of damage to the saline coupling agent which causes the release of filler particles and the composite resin matrix which can reduce the surface of the composite.^{16,17,18}

CONCLUSION

Based on the results of research that has been done, it could be concluded that cigarette smoke has an acidic pH which can reduce the hardness of composite resins. Groups 2 and 3 showed an insignificant decrease in the hardness of the composite resin with the highest mean decrease in group 2. On the other hand, group 1 which was not exposed to filter and electric cigarette smoke and only immersed in artificial saliva showed an increase in the hardness of the composite resin.

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