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Research Article

Effect of Soft Drink on Surface Roughness of Preheated and Non-Preheated Nanohybrid Composite Resins

Dewi Liliany[1§], Vanya Violetta[2]

[1]*Department of Dental Material, Faculty of Dentistry, Trisakti University, Indonesia*
[2]*Undergraduate Student, Faculty of Dentistry, Trisakti University, Indonesia*

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ABSTRACT

Introduction: Nanohybrid composite resins exhibit a smooth surface due to the presence of small filler particles. Surface roughness is affected by the low pH of soft drinks. A rough surface leads to bacterial adhesion and plaque accumulation, inducing secondary caries. Preheating involves the heating of the composite resin before application, which in turn enhances its properties. **Objective**: To analyze the difference in the surface roughness of preheated and non-preheated nanohybrid composite resins before and after immersion in soft drinks. **Methods**: Cylindrical samples of nanohybrid composite resin Filtek™ Z250 XT (10 mm in diameter and 2 mm in height) were prepared and divided into two groups: preheated and non-preheated. For samples in the preheated group, the composite resin was heated using a Micerium SpA heater. All samples were immersed in 10 mL of the soft drink for 2 h per day for 15 days. Surface roughness was measured before immersion and at 12 and 15 days of immersion using the Surface Roughness Tester Taylor Hobson S100 Series. **Results**: The surface roughness changed at every measurement in each group. Significant differences in the surface roughness of the non-preheated group of the preheated group after 12 days of immersion were not observed. However, a significant difference in the surface roughness of the preheated group after 15 days of immersion was observed. **Conclusion**: Soft drinks significantly affect the surface roughness of preheated nanohybrid composite resins after 15 days of immersion.

§ Corresponding Author
E-mail address: dewi_liliany@yahoo.com.sg (Liliany D)

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INTRODUCTION

Over the past decades, individual lifestyle in terms of food and beverage consumption especially soft drinks have dramatically increased. Soft drinks have become popular among children and teenagers.[1] Soft drinks contain a high content of glucose and acids, which are potentially cariogenic substances.[2] Typically, the pH of soft drinks is less than 4.0.[3] Clinical manifestation and diagnosis caused by soft drinks include abrasion, erosion, and dental caries.[2] Changes in the dental enamel surface affect the physical properties of restorative materials. Effects of soft drinks on surface roughness of restoration materials increase due to their intrinsic factors, such as chemical composition.[4]

There is a continuous development in composite technology, and it affords modern materials with stronger endurance against erosion, with better esthetics.[5] The surface properties of composite resins is one of the common clinical problems due to its relationship with the age of restoration.[6] Surface quality plays an important role in determining successful restoration. A rough composite surface promotes salivary protein absorption, bacterial adhesion, and plaque accumulation, leading to secondary caries.[6] A smooth restoration surface reduces the accumulation of plaque and staining on the surface, leading to better esthetic performance and extension of the material age.[7] Constituent components of the composite resin, such as the matrix, coupling agent, and certain types of filler particles, directly affect the composite resin surface. Surface roughness is mainly affected by the size and components of the filler as well as the type of filler particles.[8] Physical properties of the composite resin are affected by the degree of conversion,[9] and preheating is one of the clinically applied methods to increase the degree of conversion.[10] Preheating involves the heating of the composite resin before polymerization.[11] A previous study investigated properties of a preheated composite resin without immersion and revealed that the preheating of the composite resin affects the microhardness and not the surface roughness.[9]

Another study that investigated a nanohybrid resin composite revealed that after brushing simulation, the average roughness of the composite significantly increases.[12] Effects of soft drinks on the surface roughness of a flowable composite and resin-modified glass ionomer cement revealed that the erosive effect of cola drinks leads to significant changes in the surface roughness of restorative materials.[4] In this study, preheated and non-preheated nanohybrid composite resins were immersed in soft drinks to examine the effect on restoration materials, in order to develop knowledge in dental materials.

MATERIAL AND METHODS

In this study, laboratory experiments were conducted with designed pre-test and post-test controls. The research was performed at the Dental Material Testing Center & Center of Research (DMTcore), Faculty of Dentistry, Trisakti University. The Filtek Z250 XT A2 shade LOT NA358458 (3M ESPE) nanohybrid composite resin was used as the sample. Each group comprised 11 samples, the number of which was calculated by Lemeshow formula.[4]

Sample Preparation

The preheated sample was prepared by inserting the nanohybrid composite resin into the Micerium S.p.A Heater (Ena Heat, Micerium S.p.A., Avegno GE, Italy) and heated at 39°C. Then, the preheated composite resin was placed in a stainless-steel mold (Fig. 1) by using a plastic filling, condensed using a cement stopper, subjected to curing under light for 20 s, and then removed from the mold. The non-preheated composite resin was prepared by the same procedure, but without preheating. The samples were cylindrical, with a diameter of 10 mm and a height of 2 mm (Fig. 2).

Figure 1. Sample on the stainless-steel mold

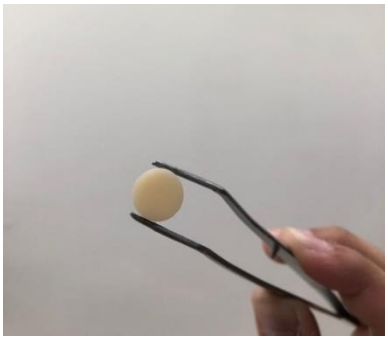

Figure 2. Nanohybrid composite resin sample

Surface Roughness Measurement

Surface roughness was measured on an optical profilometer (Taylor Hobson, Surtronic S-100 Series – S128) with a calibrated transverse length of 2.40 mm, interval (cut-off length) of 0.80 mm, and a gauge range of 400 µm. Each sample was immersed in a separate container with 10 mL of artificial saliva, and after 24 h, the surface roughness was measured before immersion into soft drinks. This measurement was carried out by placing the surface roughness tester on the working table, with the sample placed in the transverse position, and the tip of the measuring needle freely touched the sample surface. The measurement was performed in triplicate, and the mean value was calculated. The value used for this study was roughness average (Ra). Each of the preheated and non-preheated composite resin samples was immersed into 10 mL of the soft drink (Coca Cola) in separate containers for 2 h per day for 15 days. Immersion was performed 2 h per day, simulated the consumption of 4 min every day for a month (4 min × 30 days = 120 min = 2 h). For the next 22 h, each of the preheated and non-preheated composite resins was immersed into 10 mL of the artificial saliva in separate containers. This immersion was performed for 15 days. After 12 days, all samples were rinsed with distilled water. Later, the surface roughness was measured using the surface roughness tester. Twelve days of immersion simulated 12 months (a year) of soft drink consumption in real life. The immersion was continued until day 15; all samples were also rinsed with distilled water after 15 days; and the surface roughness was measured again. Fifteen days of immersion simulated 15 months of soft drink consumption in real life.

Statistical Analysis

Data were analyzed by the Shapiro–Wilk normality test, followed by the Levene test to investigate the homogeneity of variances. Next, each group was analyzed by one-way ANOVA to determine differences in the surface roughness between preheated and non-preheated nanohybrid composite resin samples before and after soft drink immersion. $P < 0.05$ was set to be significant. Statistical analysis was performed using SPPS Microsoft version 20 (IBM, USA).

RESULTS

Results revealed that differences in the surface roughness before and after the immersion of samples in soft drinks are observed and averaged (Table 1 and 2). The surface roughness increased at every measurement. Long immersion times led to increased surface roughness. However, according to statistical analysis, significant differences in the surface roughness of the non-preheated group and preheated nanohybrid composite resin before and after 12 and 15 days of immersion were not showed (Table 3) (SD 0.026), but a there was a significant difference in the surface roughness of the preheated nanohybrid composite resin before and after 15 days of immersion ($p < 0.05$) (Tables 4 and 5).

Table 1. Mean surface roughness of the preheated nanohybrid composite resin. (µm)

	Mean ± SD
Before	0.872 ± 0.2101
Day 12	1.009 ± 0.1737
Day 15	1.167 ± 0.2317

Table 2. Mean surface roughness of the non-preheated nanohybrid composite resin. (µm)

	Mean ± SD
Before	0.678 ± 0.1618
Day 12	0.878 ± 0.1331
Day 15	1.003 ± 0.3890

Table 3. ANOVA test for the non-preheated nanohybrid composite resin

N	**p**
11	0.066

Table 4. ANOVA test for the preheated nanohybrid composite resin

N	**p**
11	0.009*

Table 5. Post-hoc test for the preheated nanohybrid composite resin.

Sample	**N**	**P**
Before–Day 12	11	0.140
Before–Day 15	11	0.002*

DISCUSSION

The nanohybrid composite resin filler comprised micro-filler and nanofiller particles. It exhibits good esthetic and mechanical properties, lower contraction during polymerization, better color stability, and good retention after polishing.[13,14]

Surface roughness is one of the physical properties of a composite resin rendered as a result of the separation or biodegradation of a chemical compound due to oral changes.[15] Restorative materials should exhibit good resistance against degradation as these materials are related to the restoration age, which is also affected by physical properties.[16,17,18] Oral bacteria mainly originate from the accumulation of plaque on the tooth surface, and a rough surface increases plaque accumulation and bacterial adhesion, which are the main parameters for the etiology of secondary caries. Furthermore, the rough surface increases stains on the restoration, leading to color changes and reducing the restoration esthetics.[16,17,18]

In this study, based on the descriptive data, surface roughness increased at every measurement. Statistical analysis did not reveal a significant difference for the preheated group after 12 days of immersion and for the non-preheated group after 12 and 15 days of immersion. Nevertheless, statistical analysis revealed a significant change in the preheated group after 15 days of immersion. This result is in agreement with a study previously reported by Bayindir: The surface roughness of a composite resin changes after immersion in acidic drinks.[16] In another study, Maganur reported that soft drinks induce erosion and significantly change the surface roughness of restoration, for which a composite resin is typically used.[4]

In water absorption, water enters the matrix and diffuses into polymer micro-voids. Moreover, water spreads into the filler particles, but inorganic particles cannot absorb water molecules, leading to the accumulation of water between the fillers and matrix. The absorbed water hydrolyzes the chemical bonds between the fillers and matrix, leading to the dislodgment of the fillers and formation of micro-cracks.[19] Soft drinks, especially Coca Cola, contain carbonated water, sugar, caramel color, phosphoric acid, and caffeine.[20] In this study, the pH of Coca Cola was 2.7, which was classified as acidic, and it affected the surface roughness of the restoration. Critical oral conditions, such as pH and humidity, increase the biodegradation of the composite resin with time. These conditions lead to collapse of the polymer matrix (polymer chains become monomers), debonding of the filler and matrix, and removal of monomer residues. These processes lead to the deterioration of the composite resin properties. Low pH and phosphoric acid in soft drinks increase the surface roughness of the composite resin.[21,22]

Previous studies revealed that preheating is used to enhance physical and mechanical properties of composite resins; however, the results of this study revealed significant changes in the roughness of the preheated samples. This result is in agreement with that reported by Wetam: Preheated method was not showed significant changes to decrease the roughness of the resin composite surface.[9] The temperature of composite resins rapidly decreased after the syringe was removed from the heater. This study also revealed that 2 min after removing the syringe from the heater, the temperature decreases to 50%, and in 5 min, the temperature decreases to 90%, which is probably related to the significant change in the surface roughness of the nanohybrid preheated composite resins.[23]

CONCLUSION

In conclusion, after samples are immersed in soft drinks, their surface roughness increases. Then, preheated composite resins was not showed significant changes to decrease the roughness of the resin composite surface, because the statistic revealed that soft drinks significantly affect the surface roughness of preheated nanohybrid composites after 15 days of immersion. In future studies, the influence of soft drink consumption frequency and other variants of soft drink are still needed to explore this result further.

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CONFLICT OF INTEREST

The author declare that there are no conflicts of interest.

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