Journal of Dentistry Indonesia

Volume 30 | Number 3 Article 10

12-25-2023

The Effect of Several Electric Cigarette Puffs on Nanohybrid Composite Resin Surface Roughness

Alvi Rizqi Amaliyah
Department of Dentistry, Faculty of Medicine, Jenderal Soedirman University, Purwokerto, Indonesia, alvirizqiamaliyah.ara@gmail.com

Haris Budi Widodo
Department of Dentistry, Faculty of Medicine, Jenderal Soedirman University, Purwokerto, Indonesia, harisbudiw@gmail.com

Irfan Dwiandhono
Department of Dentistry, Faculty of Medicine, Jenderal Soedirman University, Purwokerto, Indonesia, irfan.dwiandhono@unsoed.ac.id

The Effect of Several Electric Cigarette Puffs on Nanohybrid Composite Resin Surface Roughness

Cover Page Footnote

The author is grateful to the parents for the support provided and the lecturers who guided and provided direction throughout this study, as well as the UNSOED dental laboratory for the provision of study facilities.

Journal of Dentistry Indonesia 2023, Vol. 30, No. 3, 226-232
doi: 10.14693/jdi.v30i3.1508

ORIGINAL ARTICLE

The Effect of Several Electric Cigarette Puffs on Nanohybrid Composite Resin Surface Roughness

Alvi Rizqi Amaliyah*, A. Haris Budi Widodo, Irfan Dwiandhono

Department of Dentistry, Faculty of Medicine, Jenderal Soedirman University, Purwokerto, Indonesia
**Correspondence e-mail to: alvirizqiamaliyah.ara@gmail.com*

ABSTRACT

Nanohybrid composite resin is a dental restorative material comprising micro and nano-sized fillers. When accompanied by smoking habits, it can alter the surface roughness of composite resin. **Objective:** This study aimed to determine the effect of several electric cigarette (e-cigarette) puffs on the surface roughness of nanohybrid composite resin. **Methods:** This study was conducted in the experimental laboratory with a pretest-posttest control group design using 48 nanohybrid composite resin specimens divided into six groups. Subsequently, the experimental groups were exposed to 75, 150, 225, 300, and 450 puffs of e-cigarette, and the control group was given artificial saliva immersion without exposure for 21 days. The surface roughness of specimens was measured with a surface roughness tester and evaluated through statistical analysis, including One-Way ANOVA and Post-Hoc LSD. **Results:** The average pre-test and post-test differences between groups I, II, III, IV, V, and VI were 0.013, 0.022, 0.033, 0.044, 0.065, and 0.005 µm. These results showed a significant difference in the surface roughness of nanohybrid composite resin ($p < 0.05$), with variations between all groups. **Conclusion:** This study showed that the number of e-cigarette puffs had a significant effect on the surface roughness of nanohybrid composite resin. Specifically, an increase in the number of e-cigarette puffs led to a rise in the surface roughness value of nanohybrid composite resin.

Key words: e-cigarette, nanohybrid composite resin, surface roughness

How to cite this article: Amaliyah AR, Widodo AHB, Dwiandhono I. The effect of several electric cigarette puffs on nanohybrid composite resin surface roughness. J Dent Indones. 2023;30(3): 226-232

INTRODUCTION

Smoking habit is a significant public health problem, with the prevalence of smokers in Indonesia reported at 28.8% according to Riskesdas (Baseline Health Research) data. Among the most popular types, electric cigarette (e-cigarette) is ranked third in Indonesia,[1] offering several advantages such as less coughing, reduced bad breath, and enhanced smoking cessation.[2] However, the Food and Drug Administration (FDA) in 2009, gave a warning about the dangers of various toxic substances and carcinogens contained in e-cigarette,[3] including propylene glycol, nicotine, perisadiacetyl, and carcinogenic substances.[4] The nicotine content in liquid e-cigarette causes dependence,[4] which can be measured by determining the frequency of smoking per day.[5] Excessive use of cigarette can cause lung cancer, cardiovascular disease, and the risk of neoplasms of the larynx and esophagus, leading to various dental and oral abnormalities[6]

Penn State Electronic Cigarette Dependent Index (PSDI) assesses dependence on electric smoking by measuring the number of e-cigarettes smoked per day. The scoring system includes 0–60 times given a score of 0, while 75–135, 150-210, 225-235, 300-435, and 450 times received a score of 1, 2, 3, 300–435 4, and 5, respectively.[5]

Composite resin is currently being developed to obtain the availability of various types. A significant variant is nanohybrid composite resin, comprising micro and nano-sized fillers,[7] characterized by good aesthetics, wear resistance, and strength.[8] A previous study has established that a smaller particle size of composite filler reduces the risk of microfissure, polymerization shrinkage, and discoloration.[9] Moreover, the use of composite resin accompanied by smoking habits can affect the surface roughness of composite resin, causing discoloration, water absorption, and solubility capable of shortening the life of the restoration.

Increased surface roughness can also elevate the risk of plaque and biofilm formation, thereby triggering secondary caries, periodontal disease, and gingival inflammation.[10]

The increase in surface roughness of nanohybrid composite resin due to exposure to cigarette smoke is attributed to the presence of acidic pH and heat from cigarette smoke.[11] The acidity of liquid e-cigarette originates from nicotine salts with numerous H^+ ions.[12] These ions contribute to the instability of thechemical bonds in the matrix polymer double chain, leading to brokerage, degradation, and increased surface roughness.[13] Moreover, heat from cigarette smoke increases surface roughness by enhancing water absorption into the composite resin. This absorption can break the siloxane (Si-O- Si) bond as a matrix link andfiller into silanol (Si-OH) and Silicon monoxide (Si-O), disrupting the relationship between matrix and filler.The size of the filler also has a significant effect, as larger ones result in a rougher composite surface, whilesmaller size enhances polishing ability.[14] Similarly, Chandra et al., Roman et al., and Mahross et al. stated thatacidic pH, heat from cigarette smoke, and the size of composite resin filler affected the increase in surface roughness of composite resin.[15-17]

Based on the background above, this study aimed to determine the effect of several e-cigarette puffs on the surface roughness of nanohybrid composite resin. The results are expected to provide knowledge about the effect of e-cigarette smoke on changes in the level of surface roughness of composite resin as dental restorative materials.

METHODS

Specimen recruitment

This study is a laboratory experiment with a pretest-posttest control group design method. The experiment was conducted from July to December 2022 at the Basic Dentistry Laboratory and the Dental Materials Technology Research Laboratory at Jenderal Soedirman University.

The four types of variables included in this study were independent, dependent, controlled, and uncontrolled. The dependent variable was the surface roughness of nanohybrid composite resin. The independent variable was exposure to e-cigarette smoke for 21 days with varied numbers of puffs, namely 75, 150, 225, 300, and 450, including without exposure to e-cigarette acid. The controlled variables were composite resindiameter, thickness, polymerization duration, light cure tip distance during polymerization, incubator temperature for specimens storage, duration of inhaled and exhaled e-cigarette smoke, length of specimens immersion in distilled water, and acetone. The uncontrolled variables included the temperature and pH of e-cigarette smoke.

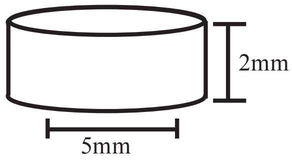

Figure 1. Specimen size

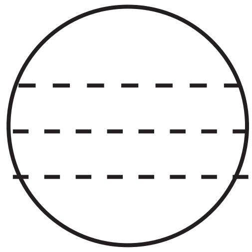

Figure 2. Distribution of composite surface roughness measurement areas.[15]

The specimen used was a cylindrical nanohybrid composite resin with a diameter of 5 mm and a thickness of 2 mm, characterized by a flat, smooth, solid, non-porous surface. Based on calculations using steel and torrie, a total of 48 specimens were obtained. These included eight groups exposed to different numbersof e-cigarette smoke, namely 75, 150, 225, 300, and 450. Additionally, there were eight specimens in the controlgroup without exposure to e-cigarette smoke.

Specific methods used

The tools used included specimen containers, tubes, e-cigarette (Aflo Pod by Movi), cylinder molds, light-cured (LED Rainbow Light-Cured), surface roughness testers (Elcometer 7062 MarSurf PS10), incubators modified with saliva (IMWS), celluloid strips (AUX-F10 Celluloid Strips by Svenska Dentorama AB), vacuum pumps, and plastic filling instruments. The materials were E-Liquid (Movi Kuy Salt Nic 30 mg with strawberry tobacco flavor), nanohybridcomposite resin (3M Filtek Z250XT), artificial saliva (Ph 7), glycerin, distilled water, acetone, and red wax (Medium Teeth Modelling Wax by Anchor Brand).

Specimens were made by printing in a stainless-steel cylinder mold with a diameter of 5 mm and a thickness of 2 mm, as shown in Figure 1. The selected thickness of 2 mm corresponded with the optimum penetration ability of LED light in the light-cure unit at a thickness of 2-2.5 mm.[9] The diameter of 5 mm wastaken from the smallest value measurable by surface roughness tester.[15]

Composite resin was filled in the mold, covered with celluloid strips, and given a load for 30 secondsto achieve a flat surface. Furthermore, composite resin was polymerized with a distance between the tip unit and composite 0.5-1 mm for 40 seconds.[9] Subsequently,

Figure 3. Specimens fixation.

Figure 4. E-cigarette smoke exposure.

properly polymerized specimens received a glycerin application to block contact with oxygen capable of forming an irregular oxygen inhibition layer (OIL) to prevent an increase in surface roughness.[18] Composite resin was removed from the mold after polymerized.

Each specimen was put into the container according to the characterization of the individual group. Moreover, all groups were put in the Incubator Modification with Saliva (IMWS) for 24 hours, adjusting to the conditions of the oral cavity. The thermostat was set at 37°C, and the flow of saliva was regulated to flow 1-3 ml per minute by adjusting the infusion knob. After 24 hours, all specimens were stabilized at room temperature for 24 hours and measured using a surface roughness tester with a properly calibrated standard stylus ($\rho = 0.94$). The measurement used a 5 m radius diamond tip from a portable surface roughness tester with a length of 1 mm, at a speed of 1 mm/s, and an accuracy of 0.01 m.[15]

Surface roughness measurements were made in three areas, which were made to guide the position of the stylus tip, as shown in Figure 2. Measurements at all three guide points yielded three values for the final mean R_a calculated for each specimen. The measurement results of these three areas were averaged to determine the surface roughness value of nanohybrid composite resin before exposure to cigarette smoke.[15] Calculation results were recorded in micrometer units (µm).[19]

All specimens that had been measured for roughness were placed in their respective group containers in the IMWS and fixed using red wax, ensuring stability, as shown in Figure 3. Subsequently, preparations were conducted before exposure to cigarette smoke. The tip of e-cigarette cartridge that was smoked was inserted into the hole in the specimen container lid, ensuring the cartridge was filled with liquid.The vacuum pump was activated and set at a suction pressure of 20mmHg.[17]

The suction process was carried out for 4 seconds and 5 seconds, respectively, to avoid remnants ofsmoke in the specimen container. Subsequently, a 60-second time lag without exposure to smoke was implemented.[20] A total of one exposure cycle was carried out for 1 minute 9 seconds and repeated accordingto the treatment of each group.

The composite that had been exposed to e-cigarette smoke was immersed in distilled water for 1 minute to remove residue and returned into IMWS, as shown in Figure 4. After 21 days, all specimens were taken from IMWS and dried using absorbent paper. The composite of the treatment group was immersed in acetone and shaken for ± 1-15 minutes to dissolve the remaining layer of dirt from cigarette smoke attached to the specimen surface.[15, 21]

Specimens were measured for roughness values after 21 days of treatment using a surface RoughnessTester. These measurements were carried out in the same three areas in the pre-test to guide the position of the stylus tip. Measurements at the three guide points yielded three final average Ra values calculated for each specimen. The results were averaged to determine the surface roughness value of nanohybrid composite resin after 21 days of treatment.[15] The subsequent change in surface roughness of composite resin was calculated from the difference between the pre-test and post-test results, which were expressed in micrometer units(µm).[19]

Data analysis

Data on the difference in mean surface roughness of nanohybrid composite resin was expressed in the numerical form of a ratio. Analysis was performed using Statistical Product and Service Solutions (SPSS) software. The data obtained were tested for normality using the Shapiro-Wilk and homogeneity tests applied to the Levene test. Data that were normally distributed and homogeneous were followed by the One-Way Anova parametric test and continued with the LSD post hoc test.

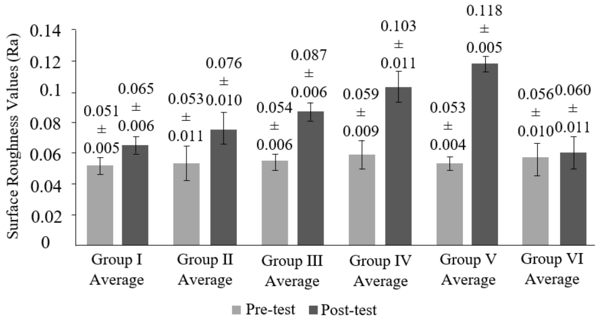

Figure 5. Graph of average surface roughness values among the experimental groups.

Table 1. The analysis of differences of surface roughness based on the numbers of puffs exposure.

Variable	n	Difference (Ra)		Sig.
		Average (SD)	F count	
75 puffs	8	0.013 (0.002)	556.4	<0.001*
150 puffs	8	0.022 (0.002)		
225 puffs	8	0.033 (0.002)		
300 puffs	8	0.044 (0.002)		
450 puffs	8	0.065 (0.005)		
Control	8	0.005 (0.002)		

*ANOVA significant difference (p≤0.05)

Table 2. The Post-hoc LSD analysis of differences of surface roughness based on the numbers of puffs exposure.

Variable	75 puffs	150 puffs	225 puffs	300 puffs	450 puffs	Control
75 puffs		0.000*	0.000*	0.000*	0.000*	0.000*
150 puffs			0.000*	0.000*	0.000*	0.000*
225 puffs				0.000*	0.000*	0.000*
300 puffs					0.000*	0.000*
450 puffs						0.000*
Control						

*Post-hoc LSD significant difference (p ≤ 0.05)

RESULTS

The data were obtained by measuring the pre-test and post-test surface roughness tests of nanohybrid composite resin specimens using a Surface Roughness Tester. Measurements were carried out three times for each specimen, and the average Ra of surface roughness test results for each specimen was taken, as shown in Figure 5.

The mean results of the pre-test and post-test in each group showed an increase in surface roughness values after treatment in groups I, II, III, IV, and V, including group VI as the control. The lowest increase occurred in group VI, and the highest was achieved in V. This showed that surface roughness value increasedas the number of e-cigarette exposure became higher.

The data analysis stage began with a normality test using Shapiro Wilk, as the number of samples was less than 50. The results of the normality test were $p > 0.05$, showing normally distributed data, which were further analyzed through the homogeneity test using the Levene Test. The results of the homogeneity test showed a value of $p = 0.225$, indicating that the data were homogeneous, as $p > 0.05$. Subsequently, the mean results of the pre-test and post-test for each specimen were calculated to determine the differences. These differences served as data for analysis using SPSS software, with the One-Way ANOVA parametric test to determine a significant difference in each variable.

Table 1 shows the results of the One-Way ANOVA test, indicating that F count > F table (556.4 > 2.438) and the p-value < 0.05, namely < 0.001. This shows that H0 is rejected and H1 is accepted, showing a significant difference in the mean surface roughness of nanohybrid composite resin. Further analysis of the data was carried out by the Post Hoc LSD test to determine the most different variables.

The results of the LSD Post Hoc test in Table 2. show all values of $p > 0.05$ which shows that there are significant differences between the six groups.

DISCUSSION

This study used specimens in the form of cylindrical nanohybrid composite resin, which was treated with exposure to e-cigarette smoke of 75, 150, 225, 300, and 450 puffs and without exposure for 21 days. Specimens were tested using Surface Roughness Tester before and after treatment. The results showed an increase in the surface roughness value of the specimens given different treatments.

The gradual increase in surface roughness of specimens in the treatment group exposed to e-cigarette smoke showed a significant effect on nanohybrid composite resin. This increase occurred due to the presence of heat and acid produced from e-cigarette smoke, which was exposed to different amounts of suction. The heat generated from e-cigarette depends on the capacity of electric power to heat the coil. Although this study did not examine the temperature of e-cigarette smoke in each group, the average coil temperature during e-liquid heating ranges from 145°C to 334°C.[22] The results showed that higher electric power generated in e-cigarette led to a greater temperature of the coil, increasing the liquid evaporation into aerosols.[23] Based on previous studies, the average temperature of e-cigarette smoke is 54° C.[24]

The high temperature generated from e-cigarette smoke increased the kinetic energy of water diffusion, causing an increase in water absorption into the composite resin.[14] The absorption occurred due to the smaller diameter of the water molecule compared to the distance between the two polymer chains of the composite resin matrix, which facilitated diffusion.[25] Absorption of water can cause a hydrolysis reaction, where water decomposes into H+ and OH- due to the presence of O in resin matrix. The decomposition causes the absorption of OH- from water into the matrix and breaks the siloxane bonds (Si-O-Si), which are analyses of the bonds connecting the matrix and filler particles. This phenomenon leads to the breaking of siloxane bonds, as well as the formation of silanol compounds (Si-OH) and Silicon monoxide (Si-O). Moreover, silicon monoxide (Si-O) is capable of reacting when in contact with water, as it experiences electron disorientation. The reaction produces Si-OH and OH-, which breaks the siloxane bonds, and the cycle continues when composite resin remains in water immersion. Prolonged cycles increase the risk of damage to the saline coupling agent, leading to the release of filler particles and an elevation in the surface roughness ofcomposite resin.[14]

The results of surface roughness measurements in groups I to V showed a gradual increase in composite resin. This showed that higher exposure to hot temperatures increased the water diffusion processin composite resin. Similarly, Sadeler et al. examined the effect of temperature on water absorption and solubility of composite resin immersed in distilled water at 5°C, 37°C, and 50°C. The results showed that higher water temperature led to increased absorption and solubility.[26]

The acidic pH of e-cigarette smoke originating from nicotine salts also plays a role in increasing the surface roughness of nanohybrid composite resin. Nicotine salt combines organic acids to become protonated and form salts. Based on standard recommendations, the average e-liquid pH is 4.9.[12]

The acidic nature of nicotine salt releases several H+ ions, which can detach from their hydroxyl groups. These released H+ ions break the chemical bonds of the double-chain polymer matrix composite resin. Furthermore, the bond contributes to the degradation of composite resin matrix capable of increasing surface roughness.[13] The H+ ions can also break the siloxane bond connecting the matrix and filler particles,thereby releasing filler particles and composite resin matrix.[15]

The results showed a gradual increase in surface roughness measurements of composite resin in groups I to V. This showed that higher exposure of composite resin to acids led to greater degradation. Similarly, Yofarindra, et al. reported an increase in surface roughness of nanohybrid composite resin after immersion in an acidic mouthwash containing ethanol for 1.5 and 3 hours.[27]

In addition to acids and heat from e-cigarette smoke, the surface roughness of composite resin was also affected by the polymer matrix composition, filler content, and filler shape. The types of composite resin matrices used in this study were TEGDMA and BisGMA, which have hydrophilic properties due to their dense and heterogeneous polymer form. These characteristics facilitated the process of water diffusion, as there are microporous between polymer groups.[25] Water diffusion that occurs can form micro voids in the polymer, thereby hydrolyzing the chemical bonds between the resin matrix and filler and causing microcracks. TEGDMA and Bis-GMA that pass-through degradation causes the polymer chains to split into monomer chains in the form of carboxylic acids, capable of accelerating the degradation process of composite resin matrix polymer.[28]

The type of composite resin filler used in this study was zirconia and silica filler which has porousproperties contributing to increased water absorption. In addition, non-grouped nano-silica can increase the surface area for liquid accumulation between the filler and the matrix. Although the form of composite resin filler also has a significant effect on increased water absorption and solubility, the type used in this study showed no correlation due to limited product information.[25] This is evident from the surface roughness testin all groups, which experienced an increase but below the average parameter of 0.2 μm.[29] Water absorptionin composite resin was further increaseddue to theexposure to acids from nicotine salts and hot temperaturesin e-cigarette smoke. This phenomenon caused an increase in surface roughness, thereby decreasing the defense of composite resin from exposure to smoke.[25]

In this study, group VI served as the control group which was soaked in artificial saliva pH 7 in an incubator at 37°C and was not exposed to e-cigarette smoke for 21 days. Saliva acts as a lubricant, buffer, self-cleanser, tooth erosion controller, acid exposure protector, enamel remineralizer, and antibacterial agent, which assists in mastication and digestion.[30] Consequently, artificial saliva was selected to simulate oral cavity conditions but not optimally described due to limitations in this study.

The artificial saliva in this study was adapted to the Fusayama Meyer formulation, comprising sodium chloride 0.4 g/L, potassium chloride 0.4 g/L, calcium chloride dihydrate 0.795 g/L, sodium sulfide nonahydrate 0.005 g/L, monosodium phosphate dihydrate 0.69 g/L, and 1 g/L urea.[31] This composition is different from natural saliva due to the absence of immunoglobulins and proteins.[32] The measurements of surface roughness of composite resin showed an increase of 0.005 μm. Similarly, Silva, et al reported an increase in the average surface roughness value of nanohybrid composite resin after immersion in artificial saliva pH 7. The increase was attributed to elevated water diffusion into composite resin which has a hydrophilic matrix, facilitating degradation and increased surface roughness.[33]

The results of statistical analysis using One-Way ANOVA and Post Hoc LSD showed a significant increase in surface roughness of composite resin in all groups. Specifically, groups I to V that were exposed to e-cigarette smoke with different amounts of suction experienced an increase in surface roughness of composite resin. Group I, which was exposed to 75 puffs, experienced the lowest compared to groups II, III, IV, and V. This increase occurred due to a slow matrix degradation process, which released filler particleson the surface of composite resin to form a porous surface. As the number of inhaled e-cigarettes increased, greater exposure to heat and acid from e-cigarette smoke led to elevated release of filler and matrix particles.

This study showed that the highest increase in surface roughness of composite resin occurred in group V, exposed to e-cigarette smoke of 450 puffs. Group VI had the lowest increase as the control was onlysubjected to water absorption. Furthermore, it was not affected by the presence of acid, as the artificial salivaused in the study had a pH of 7. These results are in line with the study conducted by Chandra et al., where e-cigarette smoke increased the surface roughness of nanohybrid composite resin, as shown by the significant difference between the control group and the treatment group.[15]

The results showed that the amount of e-cigarette puffs affected the surface roughness of nanohybrid composite resin. Specifically, a higher number of inhaled e-cigarettes resulted in a greater surface roughness value of composite resin. In addition, there were differences in surface roughness values of nanohybrid composite resin in the treatment group exposed to 75, 150, 225, 300, and 450 puffs, including the control group.

The limitations of this study included the temperature and pH of e-cigarette smoke, which were not measured due to constraints in the available tools. However, this study provided valuable insight into the effect of e-cigarette on dental fillings, showing the importance of reducing the use of composite resin fillings for individuals engaged in electric smoking habit. The results also served as a reference material to maintain the aesthetic and functional aspect of teeth for post-operative instructions by dentists after filling treatment.

CONCLUSION

In conclusion, this study showed that the amount of e-cigarette puffs had a significant effect on the surface roughness of nanohybrid composite resin. Specifically, a higher number of inhaled e-cigarette resulted in a greater surface roughness value of composite resin.

ACKNOWLEDGMENT

The author is grateful to the parents for the support provided and the lecturers who guided and provided direction throughout this study, as well as the UNSOED dental laboratory for the provision of study facilities.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

FUNDING

The authors declare that there is no funding related to the research project.

REFERENCES

1. National Health Research 2018. Ministry of Health Republic of Indonesia. 2018. Available from: https://repository.badankebijakan.kemkes.go.id/id/eprint/3514/.
2. Sobczak, A., Kosmider, L. Advantages and disadvantages of electric cigarettes. Toxics. 2023; 11(66): 1-3.
3. Food And Drug Administration. Enforcement Priorities for Electric Nicotine Delivery System (ENDS) and Other Deemed Products on the Market Without Premarket Authorization (Revised). Food and Drugs Administration. 2020.
4. Kulhanek, A., Baptistova, A. Chemical composition of electric cigarette e-liquids: Overview of current evidence of toxicity. Adiktologie. 2020; 20 (3-4):137-144.
5. Ablelo FO, Kusuma FHD, Rosdiana Y. The relationship between the frequency of smoking with stress level in late adolescents. Nurs News Jurnal Ilmiah Keperawatan. 2019; 4(1):133-44.
6. Marques, P., Piquares. L., Sanz, Maria-Jesus. An update overview of e- cigarette impact on human health. Respiratory Res. 2021; 22 (151): 1-14.
7. Anusavice K, Shen C, Rawls HR. Phillips' science of dental materials. 12th ed. St. Louis, MO: Elsevier; 2013. p. 281-5.
8. Hatrick CD, Eakle WS. Dental materials clinical applications for dental assistants and dental hygienists. 3rd ed. St. Louis, MO: Elsevier; 2016. p. 7.

9. Reziae HR, Rizi HB, Khamseh MMR, Öchsner A. A review on dental materials. Switzerland: Springer; 2020. p. 139.
10. Ansuj MDF, dos Santos IS, Marquezan M, Durand LB, Pozzobon RT. Evaluation of the surface roughness of a nanofilled composite resin submitted to different smoothing and finishing techniques. Rev Odontol UNESP. 2016; 45(2):110-4.
11. Alandia-Roman, C., Cruvinel, D. R., Pnazeri, H.Effect of cigarette smoke on color stability and surface roughness of dental composites. J Dent. 2012; 3:e73-9.
12. Harvanko AM, Havel CM, Jacob P, Benowitz NL. Characterization of nicotine salts in 23 electronic cigarette refill liquids. Nicotine Tob Res. 2020; 22(7):1239-43.
13. Diansari, V., Ningsih, D. S., Amini, H. Surface roughness evaluation of nanofiller composite resin after immersion in 50% calamansi orange juice (Citrus Microcarpa). J Syiah Kuala Dentistry Society. 2021; 6(1): 12-17
14. Van Noort R. Introduction to Dental materials. 4th ed. St. Louis, MO: Elsevier; 2013. p. 73-92.
15. Chandra J, Setyowati L, Setyabudi. Surface roughness of nanofilled and ubah composite resins exposed to kretek cigarette smoke. Conserv Dent J. 2019; 8(1):30-5.
16. Roselino Lde M, Cruvinel DR, Chinelatti MA, Pires-de-Souza Fde C. Effect of brushing and accelerated ageing on color stability and surface roughness of composites. J Dent. 2013; 41 Suppl 5:e54-61.
17. Mahross HZ, Mohamed MD, Hassan AM, Baroudi K. Effect of cigarette smoke on surface roughness of different denture base materials. J Clin Diagn Res. 2015; 9(9):ZC39-42.
18. Zakiyah D, Effendy R, Arif EA. The effect of glycerin on the surface hardness and roughness of nanofilled composite. Conserv Dent J. 2019; 8(2):104-11.
19. Mitutoyo America Corporation. Quick guide to surface roughness measurement: Reference guide for laboratory and workshop. Aurora, IL: Mitutoyo American Corporation, 2016.
20. Dautzenberg B, Bricard D. Real-time characterization of e-cigarettes use: The 1 million puffs study. J Addict Res Ther. 2015; 6(2):229.
21. Hamano N, Chiang YC, Nyamaa I, Yamaguchi H, Ino S, Hickel R, Kunzelmann KH. Effect of different surface treatments on the repair strength of a nanofilled resin-based composite. Dent Mater J. 2011; 30(4):537-45.
22. Chen W, Wang P, Ito K, Fowles J, Shusterman D, Jaques PA, Kumagai K. Measurement of heating coil temperature for e-cigarettes with a "top-coil" clearomizer. PLoS One. 2018; 13(4):e0195925.
23. Ko TJ, Kim SA. Effect of heating on physicochemical property of aerosols during vaping. Int J Environ Res Public Health. 2022; 19(3):1892.
24. Farsalinos KE, Polosa R. Safety evaluation and risk assessment of electronic cigarettes as tobacco cigarette substitutes: A systematic review. Ther Adv Drug Saf. 2014; 5(2):67-86.
25. Biradar, B., Biradar, S. Arvind, M.S. Evaluation of three effect of water on three different light cured composite restorative materials stored in water: An in vitro study. Int J Dent. 2012; 2012(5): 1-6.
26. Sadeler, R., Saedi, A., Keles, S. In vitro investigation of the effect of preheating, thermal cycling, and different chewing environtment temperature on the wear of dental composite resins. Mat Tech. 2021; 37(12): 2073-89.
27. Yofarindra BM, Damiyanti M, Herda E. Effects of immersion in mouthwash for different durations and with different ethanol concentrations on the surface roughness of nanohybrid composite resin. J Phys Conf Ser. 2018; 1073(3):032002.
28. Elwardani G, Sharaf AA, Mahmoud A. Evaluation of colour change and surface roughness of two resin-based composites when exposed to beverages commonly used by children: An in-vitro study. Eur Arch Paediatr Dent. 2019; 20(3):267-76.
29. Sakaguchi R, Ferracane J, Powers J. Craig's restorative dental materials. 4th ed. St. Louis, MO: Elsevier; 2019. p. 19.
30. Tvarijonaviciute A, Martínez-Subiela S, López-Jornet P, Lamy E. Saliva in health and disease. Switzerland: Springer; 2020. p. 11-5.
31. Sikora CL, Alfaro MF, Yuan JC, Barao VA, Sukotjo C, Mathew MT. Wear and corrosion interactions at the titanium/zirconia interface: Dental implant application. J Prosthodont. 2018; 27(9):842-52.
32. Buzalaf MA, Hannas AR, Kato MT. Saliva and dental erosion. J Appl Oral Sci. 2012; 20(5):493-502.
33. DA Silva MA, Vitti RP, Sinhoreti MA, Consani RL, Silva-Júnior JG, Tonholo J. Effect of alcoholic beverages on surface roughness and microhardness of dental composites. Dent Mater J. 2016; 35(4):621-6.

(Received April 5, 2023; Accepted November 12, 2023)