



Influence of Coca-cola on Surface Roughness and Microhardness of Flexible Denture Base Material

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Abstract

Two potential problems commonly associated with flexible denture base material are surface roughness and the reduction of microhardness due to many reasons, rough surface can cause bacterial collection and the patient feels discomfort, and the possibility of the denture scratched when the surface hardness is reduced. The aim of this study was to evaluate the influence of Coca-cola on the surface quality of the flexible denture base material represented by the surface roughness and microhardness. A total of (10) samples were prepared for this study with the dimension of (40mm, 10mm, 3mm) length, width, and height respectively from thermo-plastic flexible resin (X-flexible capsules, color; K2 , size; L\China) by the conventional methods following the manufacturer instructions. The samples were immersed in Coca-cola drink for 12 days at room temperature. This period represents the average of one year of the beverage consumption, the drink has been changing daily. The samples were marked randomly and kept in special containers, and each sample has two rectangular surfaces used for the tests. One side is used for microhardness test and the other side used for the surface roughness test. The first tests were done before immersing the samples in coca-cola as control group. And after immersing the second tests were done as experimental group. In this study the data was analyzed using Independent samples (T- test). And results showed that there is no statistically significant difference in the surface roughness of the samples before and after immersing in Coca-cola (P-value > 0,05), while the microhardness test showed statistically a significant difference (P-value < 0,05) before and after immersing in Coca-cola. The surface roughness of flexible thermoplastic resin is not affected by coca-cola drink. While the levels of mirohardsness showed decreasing after immersion in coca-cola drink. Therefore, the flexible thermoplastic material could be damaged if it is subjected to extra consumption of Coca-cola drink by the patient and this leads to lessen the amount of hardness by the time that could affect the efficiency of the prostheses, also could affect the mechanical bonding between artificial teeth and flexible denture base.

Introduction:

The invention of nylon – derived denture base material was introduced as a successful substitution to traditional denture base material, polymethyl methacrylate acrylic (PMMA). Because the latter had some problems such as, difficult to insert the undercuts, weakness, bad smell, and allergy to PMMA monomer⁽¹⁾. Therefore, in recent years soft dentures became good alternative to the hard fitted-dentures and dentures relines with soft-putty substance⁽²⁾. Soft dentures introduced as thermoplastic materials (Valplast, Flexiplast) these two types have similar proportions of polyamides (nylon plastics)⁽³⁾. The thermoplastic materials are used objectively in removable partial dentures when the esthetic matters⁽⁴⁾. Since it can engage the undercuts in hard and soft tissue to give superior retention⁽⁵⁾, and also used in complete denture construction,⁽¹⁾ and cases of over dentures for comfort and esthetic demands⁽⁶⁾. The thermoplastic means that a polymer softens by heating and hardens when it cooled, this characteristics is favorable when fabrication of dental prosthesis for each individual. It is available in four basic types; thermoplastic-acetal, thermoplastic polycarbonates, thermoplastic acrylic, and thermoplastic nylon⁽⁷⁾. According to the available evidences about this material, it was produced to be high resilient material and has the ability to abrasion resistance and difficult to broken⁽⁷⁾. It is also provide excellent retention since it has low modulus of elasticity and easily manipulated⁽⁸⁾, and it shows high value of transverse strength and tensile strength⁽⁹⁾. In addition, it provides superior esthetic outcomes (non metal clasp), no residual monomer so it is indicated to the patients allergic to monomer and also has a good strength, all of these properties make it the material of choice for removable denture construction nowadays⁽¹⁰⁾. On other side, flexible thermoplastic resin has some disadvantages as staining, water absorption, surface roughness, polishing difficulties⁽¹¹⁾. Several experiment documented that the hardness of flexible

resin is lower compared with other materials this may be due to lack of cross-linking agents⁽¹¹⁾. So it can be broken easily⁽¹²⁾. Also this material showed increasing in the surface roughness affected by many factors like the methods of polishing or denture cleansers that are used routinely^(11, 13). A rough surface collects bacterial and fungal microorganisms and cause annoyance for the patients⁽¹¹⁾, this also lead to discoloration of denture base and the possibility of cytotoxicity⁽¹⁴⁾. These two problems, surface roughness and loss of micro-hardness are commonly associated with the flexible dentures compared with conventional dentures, and they are considered to be one of the factors that lead to reduce the longevity of the dentures. Consequently this study evaluated the surface quality of the flexible thermoplastic material, includes the surface roughness and the micro-hardness, since they considered to be the most important factors of success the restorations, after immersed in the coca-cola, one of the most beverages consumed nowadays. It is considered to be acidic solution which has negative effect on the surface roughness and microhardness of many dental substances like composite resins restorative material⁽¹⁵⁾. And also over intake of coca-cola is a risky factor on the surface integrity of human enamel⁽¹⁶⁾.

Materials and methods:

Preparation of the samples:

A total of (10) samples was prepared from base plate wax with dimensions (40mm, 10mm, 3mm) length, width and height respectively⁽¹⁷⁾. By making a rectangular shape of base plate wax through heat it on Bunsen burner at acceptable temperature following the conventional methods, and after obtained the desirable shape and size of the samples smooth it properly to get a flat and smooth surface for the wax samples.

Flask preparation

The flask of these samples was done by conventional methods by using special

type of metal dental flask (for injection process), through lubricating the inner surface of the two parts of flask by separating medium(cold mold seal) to facilitate removing the mold during de-flasking. Enough amount of die stone was mixed with distilled water powder/liquid ratio according to the manufacturer's instructions and filling the lower part of flask with stone mixture till the upper edge of lower part of flask, then put 4 samples for each flask with minor sprue between them (2,5mm) in diameter and (1 cm) in length, to ensure complete injection of capsules to reach for all 4 samples, and then connected all 4 samples with a major sprue to reach the upper orifice of the upper part of the flask to provide a way for the injected capsules, as it shown in Fig. (1-A). After the first layer was dried, the exposed aspect of stone was lubricated with a fine film of separating medium (cold mold seal) to prevent adhering with the second layer of stone. Once dried, the second layer was poured by stone mixture till the upper part was filled completely then left for about (60) min to set, as it shown in Fig. (1-B).

Wax elimination of the samples

After the complete setting has accrued, the flask was placed in the clamp and then put in the water bath with boiling water for 5 min for wax elimination. After 5 min the flask was opened and washed with soap and clean water to make sure of complete wax elimination. After dried, applied a thin layer of cold mold seal again to the two parts of exposed surface of stone and left to dry for few minute.

Injection of flexible resin

Injection of the flexible capsules were done through injection system device (plastic injection machine). The flask was reheated at (65-70 C) for few min in the oven before the injection process, to prevent the shrinkage that might occur with the cold flask. At the same time the flexible capsule(X-flexible capsules, color; K2: size: L\China) was placed inside the heater machine that was operated and the temperature raised gradually till (287C) for about (15-20) minute.

After that, the flask was put in special clamp and placed inside the hydraulic press and initiated the injection process of flexible capsules with rapid pressure applied for about (5) Bar for (1) min. The time between removing the capsule from the heater and injected should be not exceed (1) min to prevent partial injection or cooling of capsule. Then the flask was removed directly after the injection was completed and left to bench – cooled before opening for about (15-20) min^(18,19).

Finishing and Polishing

After the flask was cooled, it is opened gently and all samples were finished by using disc bur to cut all sprues, then stone bur was used to eliminate excessive resin, carbide was used to smoothing the surface after removing the excess at low speed, and finally sand paper also used with low speed 1500 rpm and low pressure with constant water cooling by hand⁽²⁰⁾. The polishing step was done using the conventional lathe polishing machine, with a medium slurry pumice mixed with water by using cloth wheel for about (60) s , then used a fine grit pumice with a second cloth wheel smaller in size for about(60)s⁽²¹⁾, as it shown in Fig.(2).

Grouping of the samples

After the finishing and polishing of samples have completed, each sample was tested before immersed in coca-cola drink in one side to microhardness test and to another side to surface roughness test, these measurements used as control group. And after this, each sample was kept in special container filled with coca-cola drink at room temperature for 12 days, this period represents one year of Coca-cola consumption, and the beverage has been changing daily,as it shown in Fig.(3). After ended the protocol period the samples were rinsed using distilled water and dried to be ready for testing as experimental group⁽¹⁷⁾.

Microhardness test

In this study, surface microhardness was measured by Vicker's micro hardness tester (Matsuzawa Japan for Vicker's

microhardness) Fig.(4) with 50g load on the sample surface for 10 seconds⁽²²⁾. This device has a diamond pyramid shape indenter, the test was done through which the indentation was done for every individual sample and adapted to a results measured with VHN unite, and appears through the digital screen of the tester device. Through this formula:

Vicker's hardness(VHN)= load /Area of pyramidal indentation

One reading was documented for each individual sample and the value of mean was the average for all samples reading before and after immersion in coca-cola.

Surface roughness test

Profilometer device Fig. (5) was used to measure the surface roughness (Ra value) of the samples after & before immersed the samples in Coca-cola drink. This device has a stylus that moving forward & backward on a flat surface for a distance (1 cm) according to the device instruction to determine the surface topography. The result recording is appear on the digital screen with the (µm) unite. One reading was calculated for each independent sample, and the mean value for all samples was the average of all reading of samples before and after immersion in coca-cola for finding the effect of this beverage on the micro geometry of the flexible resin surface.

Results:

IBM SPSS statics (version 20) was used for the statistical analysis to calculate the results. The Independent Samples Test (T-test) used to calculate the results of two tests, microhardness and surface roughness. Each test was done alone for specific surface of every individual sample before & after immersing in Coca-cola beverage to compare the outcome in terms of significant difference. The confidence level was set to be 95%, and P-value was considered according to that level.

Surface roughness:

The values of mean, standard deviation and standard error mean of surface

roughness for all Samples before & after immersing in Coca-cola drink are shown in Table (1) .The value of (mean ±S.D) for the samples before immersing in Coca-cola is (1.47 ± 0.2) & after immersing is (1.73 ± 0.3) this slightly increasing in mean value considered to be statistically non-significant . Statistical analysis of data by using independent sample test (T-test) for samples before & after immersion in Coca-cola drink is listed in Table (2) .The surface roughness showed no statistically significant difference (P- value> 0.05).

Surface michrohardness:

The values of mean, standard deviation and standard error mean for all Samples before & after immersing in Coca-cola drink are shown in Table (3) The value of (mean ± S.D) for the samples before immersed = (11.03 ± 1.4) & after immersing = (7.74 ± 1.05) this results was Showed clear decreasing in the amount of hardness. Statistical analysis of data by using independent sample test (T-test) for the samples before & after immersion in Coca-cola drink is listed in Table (4) .The microhardness test showed a statistically significant difference (P- value<0.05) .

Discussion:

Thermoplastic polymer made from nylon material which belongs to polyamide family, was introduced in dentistry as a denture base material. It seems to be very advantageous to patient with allergic reaction to monomer and denture recurrent fracture because of its flexibility and high flexural and impact strength ^(23, 24). On another side, the researches on this material has reported some disadvantages like; tendency to water absorption, surface roughness, difficulties in polishing and the hardness of this resin is much lower than conventional acrylic⁽¹¹⁾. Therefore, this experiment was done to investigate the surface quality of flexible material represented by the surface roughness and microhardness after immersed in coca-cola beverage, since it is the most drink consumed nowadays, and it is considered

to be acidic solution. The statistical results of mean value for surface roughness test (Ra) before immersion of samples in coca-cola drink were (1.47 μm) and after immersion were (1.73 μm). This slight increasing is considered to be non significant statistically. (P-value > 0.05) there is no statistically significant difference in the surface roughness before & after immersion the flexible samples in coca-cola beverage. These statistical results proved that the coca-cola drink is not a risky factor on surface texture of flexible resin prosthesis, since the latter showed no difference in surface topography before & after immersion in coca-cola. From the above results, we noticed that the flexible resin material exhibit a resistance behavior against the etching effect of phosphoric acid, one of coca-cola compositions. This behavior makes it maintain of the surface integrity against the acidic beverage. This result disagrees with previous researches done by Yuna M. et al, 2016 ⁽¹⁶⁾, that found the coca-cola had effect on surface roughness of human enamel. And Abu-Naila 2010 ⁽¹⁵⁾, which stated that the regular intake of coca-cola increased the amount of surface roughness of composite resin material. This might due to the difference of the nature & compositions of material that are used. The hardness is known as, the resistance of any surface to the permanent deformation therefore the dental restorations must be acceptably hard to maintain their integrity ⁽¹⁸⁾. The statistical results of mean value for microhardness of samples before immersion were (11.03 HV) and after immersion were (7.74 HV), which are clearly decreased. (P-value<0.05) there is statistically significant difference in microhardness levels before & after immersing in coca-cola drink. This could be attributed to absence of cross-linking agent in flexible resin. In addition, this

material suffer from high water absorption and lower levels of hardness in normal condition. On another hand, some of the Coca-cola drink compositions are carbonated water and phosphoric acid. And the ability of flexible material to absorption this acid led to lessen the level of the microhardness through the potential of chemical reaction with the flexible resin ingredients that led to softening or disturbance effect for the chain of condensation reaction between diamine $\text{NH}_2\text{-(CH}_2\text{)}_6\text{-NH}_2$ & dibasic acid $\text{CO}_2\text{H-(CH}_2\text{)}_4\text{-COOH}$, which is responsible of flexible resin formation. This result agrees with study done by Abu-Naila 2010 ⁽¹⁵⁾, that found the coca-cola was decreased the amount of microhardness of composite resin, and disagrees with study done by Safari A, et al, 2013 ⁽¹⁷⁾, that found the hardness of soft liner with acrylic base does not affect by coca-cola consumption.

Conclusions

In conclusion, the object was to assess the effect of coca-cola consumption on flexible denture base material. Within the limitations that associated of this experiment the results were calculated for the surface roughness & microhardness as following:

1-The Coca-cola drink had no effect on the surface texture of flexible resin. The amount of surface roughness of flexible denture was not changed before & after immersed the study samples in Coca-cola beverage.

2-The levels of microhardness of flexible resin were decreased after immersed in coca-cola drink. That means, the coca-cola is considered to be a negative factor on the hardness of flexible denture base material.

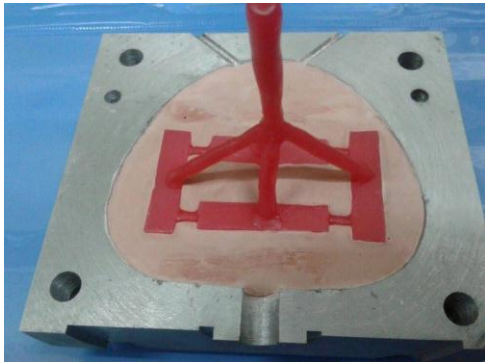


Fig.(1-A): First layer of flask.

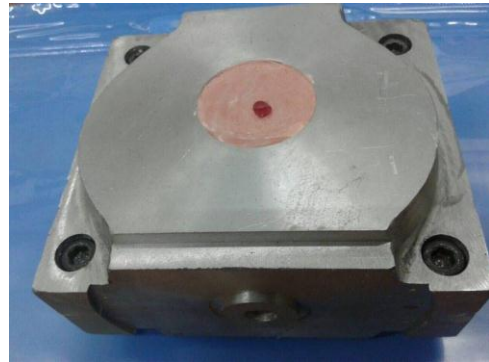


Fig.(1-B): Second layer left to set.



Fig. (2): Samples used in study.



Fig. (3): Samples immersed in coca-cola



Fig. (4): Michrohardness test machine.



Fig. (5): Surface roughness device.

Table (1): Group Statistics of mean, std deviation and std error mean of roughness for all samples before & after immersion.

Groups		N	Mean	Std. Deviation	Std. Error Mean
Surface	Before	10	1.4740	.25246	.07984
Roughness	After	10	1.7360	.38091	.12045

Table (2): Independent Samples Test (T- test) of surface roughness for all samples before & after immersion.

	Levene's Test for Equality of Variances	t-test for Equality of Means								
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Surface	Equal variances assumed	1.488	.238	-1.813	18	.087	-.26200	.14451	-.56560	.04160
Roughness	Equal variances not assumed			-1.813	15.628	.089	-.26200	.14451	-.56894	.04494

P-value>0.05 No significant difference

Table (3) :Group statistics of mean, std deviation and std error mean of michrohardness for all samples before & after immersion.

Groups		N	Mean	Std. Deviation	Std. Error Mean
Hard	Before	10	11.0380	1.49003	.47119
ness	After	10	7.7420	1.05041	.33217

Table (4): Independent Samples Test T-test of microhardness for all samples before & after immersion.

	Levene's Test for Equality of Variances		t-test for Equality of Means							
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		
								Lower	Upper	
Hardness	Equal variances assumed	1.611	.221	5.717	18	.009	3.29600	.57650	2.08481	4.50719
	Equal variances not assumed			5.717	16.174	.009	3.29600	.57650	2.07494	4.51706

P-value<0.05 significant difference.

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