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The effect of olive oil coating material on the water sorption, solubility and wettability of acrylic resin denture base material

(Water Sorption, Solubility and Wettability of Acrylic Resin)

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ABSTRACT

Aims: To evaluate the effect of olive oil as a coating on the water sorption, solubility and wettability of heat cured acrylic resin denture base material.

Materials and Methods: Fourty samples were prepared from vertex heat cured acrylic resin. 30 samples were used for water sorption and solubility test and these samples were subdivided into three subgroups: the control group (without treatment), the second group were immersed in olive oil for 48 hours after preparation and dryness then washed and dried , the third group were immersed in distilled water for 48 hours then dried and immersed in olive oil for 48 hours then washed and dried. The other 10 samples were tested for wettability, these samples were divided into two groups: the control group (immersed in distilled water for 24 hours then tested) and the second group were the samples immersed in olive oil for 48 hours then washed, dried and tested by the sessile drop method.

Results: It is showed that after one week there were significant increase in water sorption for the coated samples but not significant difference in solubility of these samples in comparison with the control group. After one month there were not significant difference in water sorption between the groups but the coated samples showed significant increase in solubility in comparison with the control group. Regarding wettability, the coated samples showed significant decrease in wettability in comparison with the control group.

Conclusions: It is concluded that the use of olive oil as a coating for acrylic resin increase the water sorption after one week, incresase the solubility after one month and decrease the wettability of the material.

Keywords: Olive oil, water sorption, solubility, wettability, acrylic resin.

INTRODUCTION

The acrylic resins were so well received by the dental profession that by 1946, 98% of all denture bases were constructed from methylmethacrylate polymers or co-polymers.[1] Prediction of the service life of acrylic resin material is difficult since many environmental factors affects durability. One of these properties of acrylic resin is water sorption and release, which causes dimensional instability, thereby subjecting the material to internal stresses that may result in crack formation and, eventually, fractures of the denture.[2,3]

The oral environment necessarily facilitates water sorption from the saliva to the resin which is a polar material.[4] Sorption of the material represents the amount of water absorption on the surface and into the body of material, the sorption of polymethylmethacrylate is facilitated by its polarity and the mechanism primary responsible for the ingress of water is diffusion.[5]

The water absorbed into the material act as a plasticizer and decreases the mechanical properties such as hardness, transverse strength and fatigue limit.[6] water sorption can also influence dimensional stability.[3,7,8] whereas solubility represent the mass of the soluble materials from polymer. The only soluble materials present in the denture base resins are initiators, plasticizers and free monomer.[9-11]

Water sorption and solubility were measured by means of mass change in the materials after water saturation and dehydration.[12-14]

Another important property for acrylic resin denture base material is wettability, wettability of denture base and denture relining materials is one of the most important properties for denture retention because it provides a condition in which saliva will spread over the surfaces with ease. [15,16] Wettability is a measure of the affinity of a liquid for a solid as indicated by spreading of a drop. [17] The quantitative measure of the wettability process is taken to be the contact angle (0) that the adhesive makes with the adherant surface.[18]

Low contact angle indicates good wettability. As the contact angle increases, the wettability decreases.[19] Due to the importance of these properties in the clinical performance of a denture, this study has the objective of analyzing the effect of olive oil as a coating material on these properties.

Olive oil, a traditional food product with thousands of years of history, is continually evolving toward a more competitive global market. [20] In the last couple of years the number of reports describing the beneficial properties of Olive oil has dramatically increased.[21] Recent studies demonstrate that Olive oil polyphenols are powerful antioxidants, both in vitro and vivo, and posses other potent biological activities that could account for their beneficial health effects. [21-24] Jaffer And kandil[25] used this oil as a coating for acrylic resin denture base and found that it is beneficial in reducing monomer leach from it. Coating would be advantageous as the surface properties alone are modified, and bulk properties are retained.[26]

Materials and Methods

The total number of samples used in this study were fourty samples. Thirty samples were used for the water sorption and solubility test, ten samples were used for the wettability test. All the samples were prepared from heat cured acrylic resin(Vertex). The resins were mixed at powder/liquid ratio of (2.5/1) by weight [27]. The mixture was covered and left to reach the dough stage at room temperature. Then the moulds filled with the dough acrylic resin, the flasks were closed and maintained under compression until the metal edges of the flask closed together in a hydraulic bench press for 15 minutes. Curing was accomplished in a thermostatically controlled water bath at 74°C for 90 minutes, then at 100°C for 30 minutes[28]. After deflasking, specimens were removed and excess material was cut away.

Water Sorption and Solubility test: The acrylic resin specimens for the water sorption and solubility were prepared as discs with a dimension of 50 ± 1 mm in diameter and 0.5 ± 0.1mm thickness[29]. The prepared samples were divided into three groups, each group contain ten samples:

1. The first group is the control (referred to as C) : which include the samples that were evaluated without any treatment, these samples subdivided into two subgroups: five samples were tested after one week and five samples were tested after one month of storage in distilled water for water sorption and solubility.

2. The second group (referred to as O) after preparation these samples were dried in silica gel and immersed in olive oil container for 48 hour and then washed thoroughly with distilled water and then dried[25], these samples subdivided into two subgroups : five samples were tested after one week and five samples were tested after one month of storage in distilled water for water sorption and solubility.

3. The third group (referred to as DO) after preparation these samples were immersed in distilled water for 48 hours(to relesase the residual monomer) and then dried in silica gel and immersed in olive oil container for 48 hour and then washed thoroughly with distilled water and then dried[25], these samples subdivided into two subgroups : five samples were tested after one week and five samples were tested after one month of storage in distilled water for water sorption and solubility.

All the above mentioned specimens were dried over silica gel in a desiccator at 37 °C and weighed to an accuracy of 0.0001 g using an electronic balance (Mettler PM 460 , Germany). This was considered to be the initial weight of the specimen (W1). Specimens then were immersed in distilled water, each specimen being in separate containers. The specimens subsequently were removed from their containers at 1 week and 1 month. Excess water was removed by blotting with filter paper and the weight of the specimen was recorded (W2) at each ocassion.

This represent the weight of the specimen after absorption of the distilled water. The amount of soluble materials lost was measured by drying the specimens in the desiccator after each absorption cycle (one week and one month) and recorded as (W3). The percentage of absorption and solubility were determined as follows [29] :

$$(1)\ \text{Absorption}\,\% = \frac{(W2 - W3)\,g}{(W1)\,g} \times 100$$
$$= \frac{(\text{Weight after absorption} - \text{final weight after desication})\,g}{(\text{Initial weight})\,g} \times 100$$
$$(2)\ \text{Solubility}\,\% = \frac{(W1 - W3)\,g}{(W1)\,g} \times 100$$
$$= \frac{(\text{Initial weight} - \text{final weight after desication})\,g}{(\text{Initial weight})\,g} \times 100$$

Wettability test

Ten rectangular samples(20*15*1.5mm) were used for this test, [30] five samples were the control that after preparation immersed in distilled water for 24 hours,[31] while the other five samples were immersed in olive oil container for 48 hour and then washed thoroughly with distilled water [25].

Contact Angle Measurement

The measurement of contact angle was performed by a sessile drop method[32]
Contact angle measurement was calculated by dropping 15 µl of deionized water applied with micropipette on specimen surface 2 cm above the surface, the image of three drops for each specimen was captured with a digital camera (DCR-SR45E Sony Japan) situated at a distance of 20 cm from pipette tip. [33]
An average of each specimen was calculated. Contact Angle (CA) degree was measured using AutoCad.2008.18. Contact angle measurement (Figure 1) was recorded by the angle between the tangent line and the resin surface by the sessile drop method. [34]
The statistics used for analyzing the results of this study were One Way Analysis Of Variance(ANOVA), Duncan's multiple range test and paired T-test.

Results

Water Sorption Test

It is shown from table (1) that there were significant differences between water sorption after one week and one month, only for the olive oil group. After first week there were significant differences in water sorption between the three groups (table 2) with the control group having the least water sorption and the DO group having the highest water sorption (figure 2) while after one month there were no significant differences between the three groups .

Solubility test

It is shown from table (3) that there were significant differences between solubility after one week and one month for the three groups. Table (4) showed that there were no significant differences in solubility between the three groups after one week while there were significant differences between the groups after one month. Figure (3) showed that the control group has the least solubility while the O and DO group have more solubility.

Wettability Test

Table (5) showed the group statistics for the control and olive oil group and Table (6) showed that there were significant differences in wettability between the two groups.

Discussion

Water sorption

According to Harper et al the weight change of the specimens was the combination of increase in weight due to water sorption and loss in weight caused by leaching of the monomer. [35]

Water sorption occurs mainly as a direct absorption by the resin. [36] The sorption of poly methylmethacrylate is facilitated by its polarity and the mechanism primary responsible for ingress of water is diffusion. [5] Water sorption always occurs in acrylic resin independent of surface conditions. [37]
So water will diffuses into the three groups of samples at different rates due to the presence of coating. The release of residual monomer also occur at different rates due to the presence of olive oil coating as it is proved to be effective in

reducing the monomer release from the coated samples. [25] In the control group the water molecules will be easily enter and get out of the samples while in coated samples the water enterance will be easier (from high to low concentration gradient in addition to the polarity of acrylic resin) than getting out of the sample, so the net wet gain in coated samples will be more than the control uncoated samples. So there will be more water sorption for coated samples than control samples after one week. After one month there were no significant difference in water sorption between the coated and control group, as one might expect that a typical polymeric dental material to become saturated with its aqueous environment within 1–2 months after placement.[4] In addition to the possibility of release of most of the coating material (olive oil) to water after this period (one month).

Solubility

Water solubility was determined according to loss of mass from polymers.[11] Solubility is directly related to residual monomer releasing.[37] There were no significant differences in solubility of the three groups after one week. The coated groups release lower residual monomer due to the presence of coating.[25] The control group may not release all of its absorbed water and residual monomer which may be bonded chemically with the material. After one month there were significant differences in solubility between the three groups, water molecules can easily penetrate the polymer network allowing the diffusion of
unbound/uncured monomers and/or additives from the material.[38-40] In coated samples, after one month the absorbed water may release the coating olive oil (additive) with the entrapped soluble materials, so it shows significant increase in solubility in comparison with the control group.

Wettability

Regarding wettability test, it is shown that the coated samples showed significant decrease in wettability in comparison with the control group. This indicates that the olive oil is present as a coating on the surface of acrylic and leads to increasing the contact angle of water molecules on the coated samples.

Conclusions

It is concluded that the use of olive oil as a coating on the acrylic resin denture base material leads to:

1. increase in the water sorption of acrylic after one week
2. increase in the solubility of acrylic after one month
3. decrease in the wettability of the surface of acrylic

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Table (1): t-test of water sorption for each group between one week and one month

Groups		T	Df	p-value
Control	Water sorption 1 week Water sorption 1 month	-1.328	4	0.255
Olive	Water sorption 1 week Water sorption 1 month	-4.704	4	0.009*
Distalled water-olive	Water sorption 1 week Water sorption 1 month	2.164	4	0.096

* Significant difference at $p<0.05$, df:Degree of freedom

Table (2): one way analysis of variance for water sorption between the groups after one week and one month

		Sum of squares	Df	Mean square	F	Sig.
Water sorption 1 week	Between groups Within groups Total	0.063 0.013 0.076	2 12 14	0.032 0.001	29.345	0.000*
Water sorption 1 month	Between groups Within groups Total	0.008 0.040 0.084	2 12 14	44.280 2.417	1.253	0.320

* Significant difference at p<0.05, df: Degree of freedom.

Table (3): t-test of solubility for each group between one week and one month

Groups		T	Df	p-value
Control	Solubility 1 week Solubility 1 month	-4.089	4	0.015*
Olive	Solubility 1 week Solubility 1 month	-4.210	4	0.014*
Distalled water-olive	Solubility 1 week Solubility 1 month	-13.114	4	0.000*

* Significant difference at p<0.05, df: Degree of freedom.

Table (4): one way analysis of variance for solubility between the groups after one week and one month

		Sum of squares	Df	Mean square	F	Sig.
Solubility 1 week	Between groups Within groups Total	0.004 0.017 0.021	2 12 14	0.002 0.001	1. 463	0.270
Solubility 1 month	Between groups Within groups Total	0.061 0.021 0.082	2 12 14	0.030 0.002	17.290	0.000*

* Significant difference at p<0.05, df:Degree of freedom.

Table (5): the group statistics for wettability test

	group	N	mean	Std.deviation	SE mean
Wettability test	Control	5	46.40	2.074	.927
	Olive	5	52.20	1.924	.860

Table (6): the independent sample test for wettability

	t	Df	p-value
Wettability test	-4.585	8	0.002*

* Significant difference at p<0.05, df:Degree of freedom.

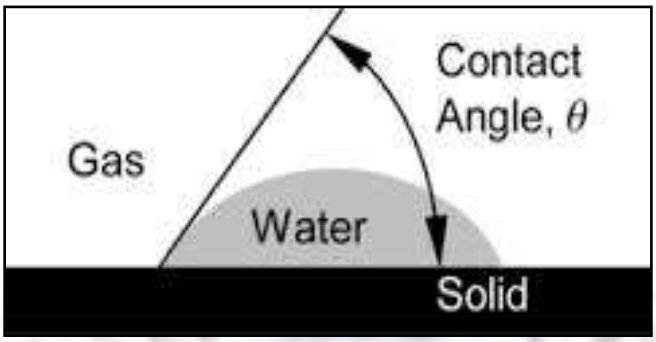

Figure (1): contact angle measurement

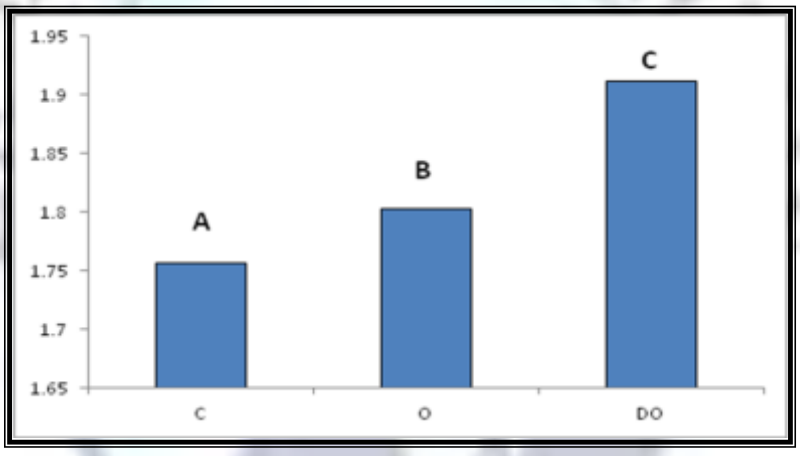

Figure (2): water sorption between the groups after one week.

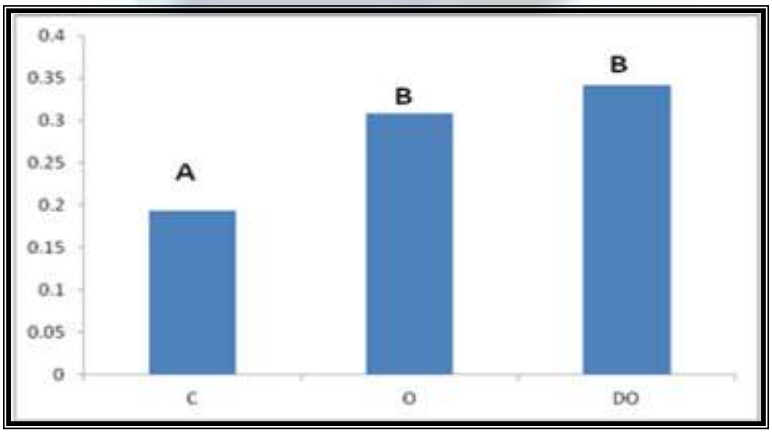

Figure (3): solubility between the groups after one month.