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Effect of Relining Curing Methods on Some Properties of Acrylic Resin Denture Base (Part II)

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الخلاصة

الأهداف: التحقق في تأثير التبطين باستخدام طريقتين في العلاج هما: (حمام الماء ، أو الموجات الدقيقة) على بعض الخصائص (صلابة السطح، اللون ، مونومر المتبقية، والمسامية) من راتنج الاكريلي لقاعدة أسنان المبطنة. **المواد وطرائق العمل**: تم إعداد الدراسة من قبل ٣٢٠ عينة، وتنقسم إلى جزأين ، الجزء الأول يدرسون صلابة السطح، خواص اللون ، مونيمر المتبقية ، والمسامية لعينات تمثل قاعدة المبطنة المعالجه بطريقة حمام مائي ، طريقة المعالجة، وعينات من الجزء الثاني معالجه عن طريق الموجات الدقيقة ، ثم تم تقييم تأثير إعادة تبطينها بطريقتين ،علاج (حمام المياه ، و الموجات الدقيقة). عينات ذات أبعاد(٣٠ × ١٥ × ٣ ± ٠.٠٣mm)لاختبار صلابة السطح ،(٤٥ × ١٠ × ٢.٥mm)أعدت للون اختبار الخواص ، ٢٠ × ٢٠ × ٣mm لاختبار مونومر المتبقية في هذه الدراسة. تم استخدام تحليل التباين (ANOVA) ودنكن اختبارات متعددة للتحليل الإحصائي. **النتائج**: اظهرت النتائج ان صلابة سطح قاعدة الطقم معالجه عن طريق الموجات الدقيقة أعلى بكثير من قاعدة طقم علاجه عن طريق حمام مائي (في P = ٠.٠٥)، وجميع العينات المبطنة أظهرت ارتفاع كبير الامتصاصية، وأظهرت أن نفاذ مونومر كان أعلى في اليوم الأول. **الاستنتاجات**: ان صلابة السطح، وخواص اللون ، مونيمر المتبقية ، والمسامية من قاعدة راتنج الاكريلية بواسطة التبطين. أعطى الموجات الدقيقة طريقة المعالجة الميكانيكية الأفضل ، والخصائص الفيزيائية للقاعدة الاكريلية والراتنج المبطن. كان كمية المونيمر المتبقية في طريقة المعالجة بالموجات الدقيقة الأقل. أعطى كلا طرائق العلاج عينات خالية المسامية.

ABSTRACT

Aims: To investigate the effect of relining by using two curing methods (water bath, or microwave) on some properties (surface hardness, color property, residual monomer, and porosity) of relined acrylic resin denture base. **Materials and methods:** The study was done by preparing 320 samples, divided into two parts, the first part involved studying surface hardness, color property, residual monomer, and porosity of samples representing a denture base cured by water bath curing method, and the samples of second part cured by microwave curing method, then the effect of relining by the two curing methods (water bath, and microwave) were evaluated. Samples with dimensions of 30×15×3 ± 0.03mm for the indentation hardness test, 45×10×2.5mm for the color property test, 20×20×3mm for residual monomer test were prepared in this study. Analysis of variance (ANOVA) and Duncan's multiple range tests were used for statistical analysis. **Results:** surface hardness of denture base cured by microwave was significantly higher (at P=0.05) than denture base cured by water bath, all the relined samples has significant higher absorbance, and showed that the elusion of monomer was higher at the 1st day. **Conclusions:** Surface hardness, color property and residual monomer of the acrylic resin denture base were affected by relining. Microwave curing method gave better mechanical, and physical properties of the relined acrylic resin denture base, the amount of residual monomer was less in the microwave curing method. Both curing methods gave samples free from porosities.

Key words: Microwave curing, Relining denture base, Residual monomer.

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INTRODUCTION

A critical part of complete denture service is the maintenance of the adaptation of denture base to the mucosa covering the residual ridges. Residual ridges can be described as plastic in nature, always changing in topography and structure.(1)

One popular method for compensating a compromised fit of existing denture is the relining. Relining is defined as "the procedure used to resurface the tissue side of a removable dental prosthesis with new

base material, thus producing an accurate adaptation to the denture foundation area".[2]

Since microwave technique was applied for resin cured by microwave technique, and conventional water bath technique.[3-6] The present study has been designed to study and compare between the two curing methods (water bath, and microwave) and their effect on the properties of denture base after relining by using the two curing methods.

MATERIALS AND METHODS

In this study two heat cured resins were used (Major base 2, and Quayle Dental heat cure acrylic resin denture base materials). Three hundred twenty samples were prepared; half of them were prepared from Major heat curing resin, while the other half was prepared from Quayle dental heat curing resin. The study was divided into two parts (Figure 1):

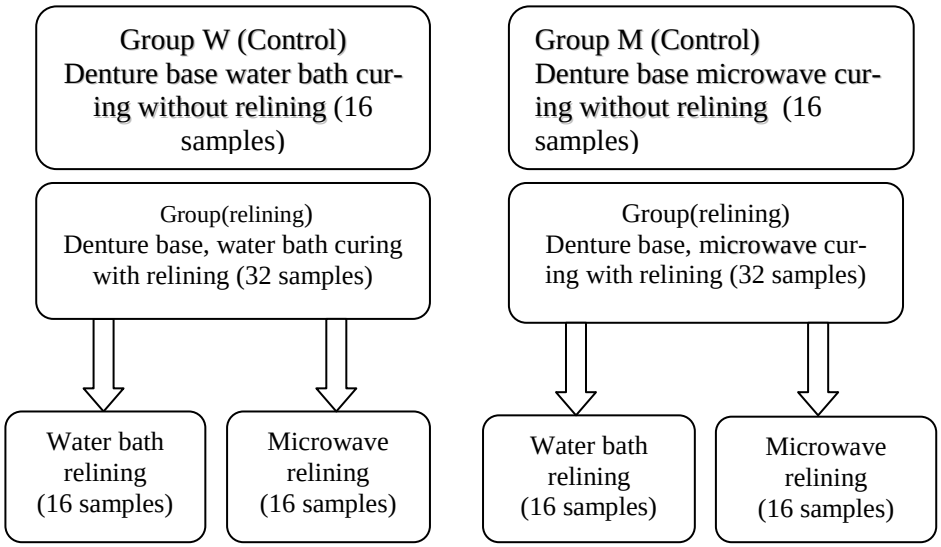

Figure (1): Experimental Design of the two parts the Study.

1. Part W(Water bath): involved studying surface hardness, color property, residual monomer, and porosity properties of samples representing a denture base cured by water bath curing method, then the effect of relining by two curing methods (water bath and, microwave) were studied.

2. Part M(Microwave): involved studying the mechanical, and physical properties of samples representing a denture base cured by microwave curing method, then the effect of relining by two curing methods (water bath, and microwave) were studied.

The samples (control group) were prepared by placing a sheet of wax against a glass slab; the sheets were cut by using a sharp wax knife to the desired length, and width specified for each test. According to the results in part I of this study, the thickness of 1 mm relining material: 1.5mm. of denture base was choose in this study as 1mm. of reduction of denture base before relining was taken by many authors.[1,7-11]

The acrylic polymer and monomer were mixed. The acrylic dough was applied over the tissue surface of the samples, and then packing, curing, and deflasking were proceeded.

Hardness Test: Ninety six samples were prepared with dimensions of 30×15×3 ± 0.03 mm, for relined samples, the ratio of relining to denture base was 1.2:1.8mm.The samples were stored in distilled water at 37°C for 48hr. before testing. The polished and relined surfaces were tested for hardness at five different locations then the mean is taken for each surface.

The test was done by using Rockwell hardness tester, equipped with an indenter in the form of round steel ball of 6.35 mm. in diameter. The sample was first subjected to a fixed minor load of 10 kg, then load of 50

kg was applied to the sample and the Rockwell hardness number was recorded after application of this load by 15 sec. [12]

Color Property Test: Ninety six samples were prepared with dimensions of 45×10×2.5 mm (length, width, and thickness) respectively, for the relined samples the ratio of relining material to denture base was 1:1.5 mm. The acrylic samples were stored in the distilled water for 7 days at 37°C ±1°C before testing. The assessment of color property was performed using an ultra violet visible spectrophotometer (CECIL 2000), it is a photometric device used to measure the light transmitted or absorbed within a specific material. The absorbed light is measured with accuracy up to 0.001.[13-15]

Residual Monomer Test: One hundred eighty two samples were prepared with dimensions of 20×20×3 mm (length, width and thickness) respectively, for all relined samples the ratio of relining to denture base was 1.2:1.8mm. Two additional groups were prepared in this study; one represented double curing by water bath curing method, and the other represented double curing by microwave curing method.

Each sample was introduced in a sealed glass flask containing 10 ml. of distilled water at 37°C. at appropriate time intervals (24 hr. 48hr.,3rd ,4th ,5th,6th,and 7th days) , the supernatants were removed and replaced by 10 ml of fresh distilled water. The time dependence of the monomer concentration was followed by monitoring the amount of monomer present in the supernatant medium using a (CECIL 2000) ultraviolet-visible spectrophotometer (λ=254 nm). [5] A linear calibration curve of methyl methacrylate (MMA) concentration as a function of absorbance at 254 nm. was obtained using MMA standard aqueous solutions in the range of 0.025-0.5 mg/ml. The results were expressed as a percent of released residual monomer mass with respect to the weight of the specimen [5].

Porosity Test: All samples prepared in this study were evaluated for the presence of porosity by examining them under reflecting light microscope (LOMO Micmed 2), using ×10 and ×40 magnifications respectively.[3,4,6] Statistical analyses used in this study were one way analysis of variance and Duncan's multiple range tests.

RESULTS

Hardness Test:The one way analysis of variance (ANOVA) is shown in table (1).

Table (1): The One Way Analysis of Variance (ANOVA) of the Surface Hardness of the Denture Base for the Control, and Relined Groups.

	Sum of square	Df	Means square	F	Sig.
Major	2099.97	5	419.99	89.96	0.000
Between group within group Total	196.08	42	4.67		
	2296.05	47			
QD	2332.5	5	466.5	200.76	0.000
Between group within group Total	97.59	42	2.32		
	2430.09	47			

Df = degree of freedom, F=F value, Sig.= Significance.

The Duncan's multiple range test (Figures 2), showed that the surface hardness of the denture base cured by microwave curing method was significantly higher (at *P*=0.05) than denture base cured by water bath curing method. The test also showed that all the denture base samples after relining showed a significant reduction in surface hardness despite of the curing method of relining.

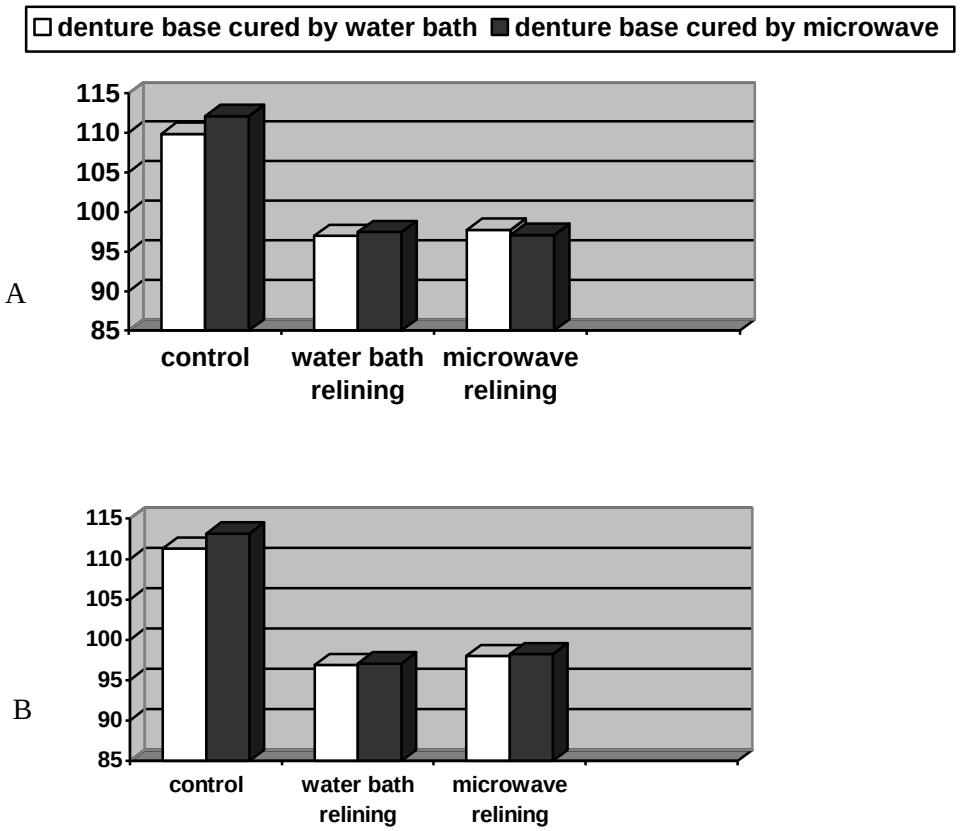

Figure (2): Means of the Surface Hardness of the Denture Base for the Control, and Reilned Groups. (Major-A, QD-B)

Color property Test: The one way analysis of variance (ANOVA) is shown in table (2).The Duncan's multiple range test (Figure 3)

Table (2): The One Way Analysis of Variance (ANOVA) of the Absorbance for the Control, and Relined Groups.

	Sum of square	Df.	Means square	F	Sig.
Major	0.004	5	0.000	1466.66	0.000
Between group within group total	0.000	42	0.000		
	0.004	47			
QD	0.004	5	0.000	890.69	0.000
Between group within group total	0.000	42	0.000		
	0.004	47			

Df = degree of freedom. F = F value. Sig. = Significance.

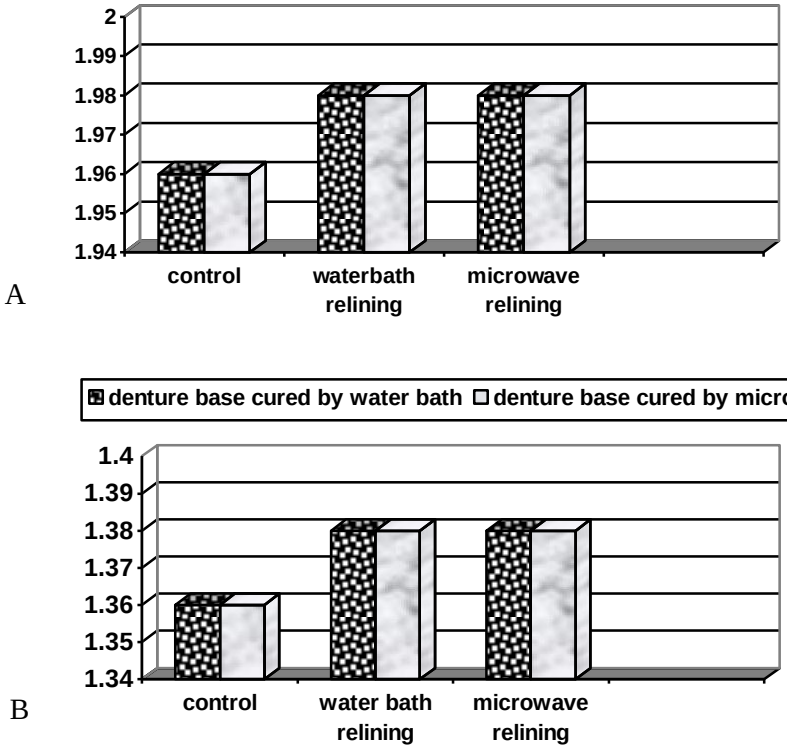

Figure (3): Means of the Absorbance (nm) for the Control, and Relined Groups. (Major-A, QD-B)

Shows that all the relined samples had an absorbance significantly higher than the control group at (*P*=0.05). The test showed that there was no significant difference between the curing methods on the color property of the denture base. The test also showed that there was a significant difference in color property (absorbance) between the two denture base materials (Major and QD).

***Residual Monomer Test*:** The one way analysis of variance (ANOVA) of the percent of released monomer with respect to the weight of the specimens (%W/W), of the 1st, 2nd, 3rd ……. 7th day, was shown in table (3).

Table (3): The One Way Analysis of Variance (ANOVA) of the Percent of Released Monomer with Respect to the Weight of the Specimens (%W/W), of the Control, Relined, and Double Curing Groups.

	Sum of square	Df.	Means square	F	Sig.
Major	0.0067	7	0.0009	0.86	0.544
Between group within group total	0.0534	48	0.0001		
	0.0601	55			
QD	0.0067	7	0.0009	0.88	0.531
Between group within group total	0.0529	48	0.0011		
	0.0596	55			

Df = degree of freedom, F = F value, Sig. = Significance.

The Duncan's multiple range tests (Figure 4) showed that the elusion of monomer was higher at the 1st day, then the 2nd, 3rd and 4th day. From the 5th to the 7th days there were no monomer elusions. This means that the elusion of monomer was higher at the 1st day then declines till the 4th day.

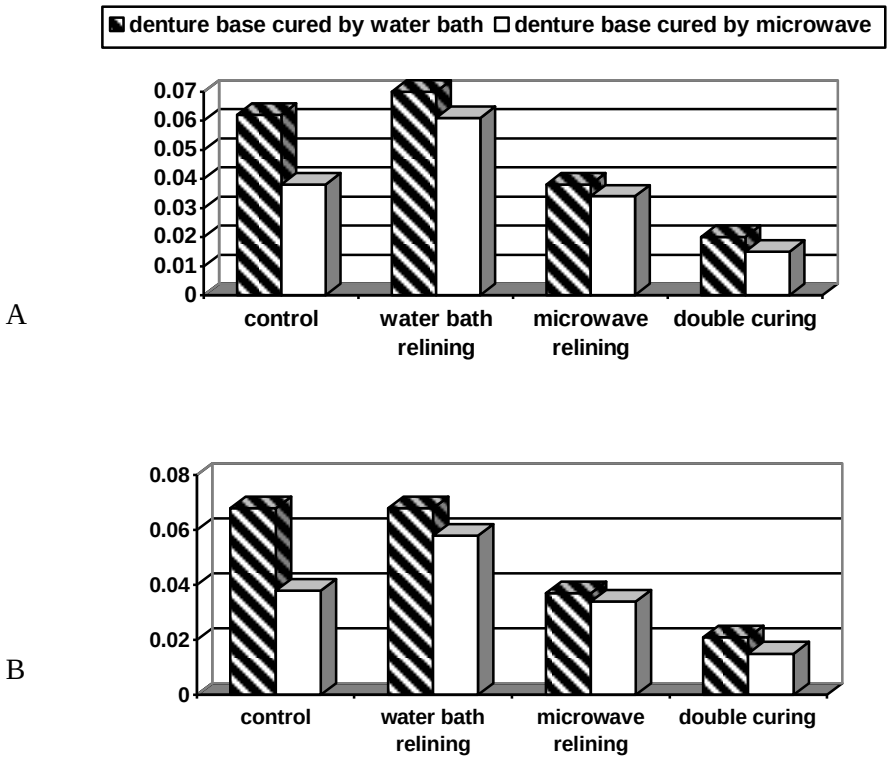

Figure (4): Means of the Percent of Released Monomer with Respect to the Weight of the Specimens (%W/W), of the Control, Relined, and Double Curing Groups. (Major-A, QD-B)

Two additional groups were prepared in this test, one representing double curing by water bath curing method, and the other group was double curing by microwave curing method. The one way analysis of variance (ANOVA) is shown in Table (4).

Table (4): The One Way Analysis of Variance (ANOVA) of the Percent of Released Monomer with Respect to the Weight of the Specimens (%W/W), of the Days being Tested.

	Sum of square	Df.	Means square	F	Sig.
Major	0.045	6	0.007	25.75	0.000
Between group within group total	0.014	49	0.000		
	0.059	55			
QD	0.045	6	0.007	25.21	0.000
Between group within group total	0.014	49	0.000		
	0.06	55			

DF = degree of freedom, F = F value, Sig. = Significance.

The Duncan's multiple range test of the percent of released monomer (Figure 5) Showed that there was no significant difference in the percent of released monomer between the control, and relined groups. The double curing showed less amount of residual monomer than the control groups. The microwave curing method showed less amount of residual monomer than the water bath curing method.

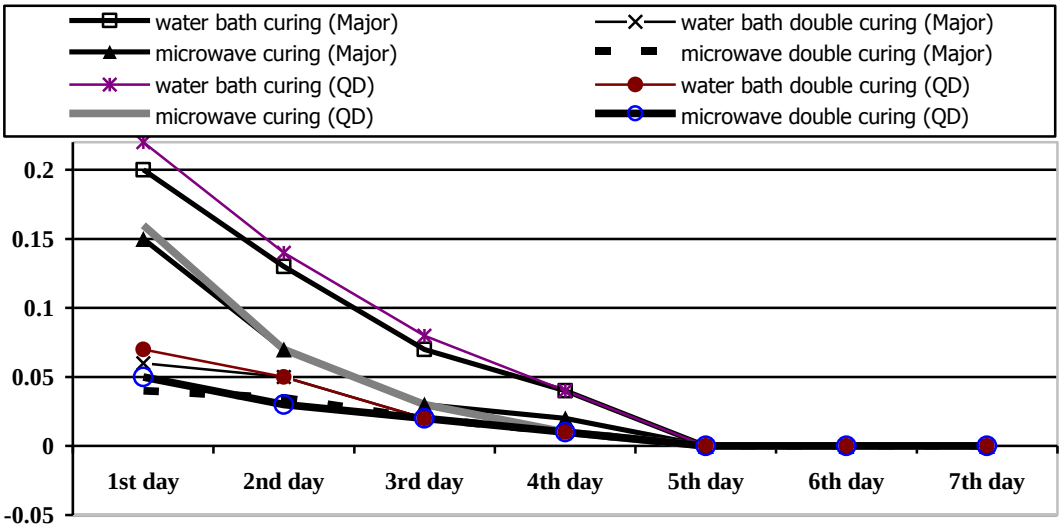

Figure 5: Percent of Released Residual Monomer for Both Curing Techniques in Seven Days.

Porosity Test: The results of this study showed that all the samples prepared in this study were free from porosity, whether control or relined groups, or cured by water bath or microwave.

DISCUSSION

Surface Hardness Test: The term hardness is used to describe the resistance of a material to penetration when indented by a hard object, a part from scratch or abrasion resistance. However, the hardness of a material is by no mean precise and several methods of evaluating this property have been developed, including Vickers, Rockwell, Knoop tests. [16]

In this study the Rockwell hardness test was used. The results in table (1) and figure (2) shows that the denture base after relining despite of the curing method used, had a decrease in the surface hardness of the denture base at P = 0.05. This could be explained by water sorption phenomenon [17, 18], the water sorption occurs from the water present in the surrounding investment material (stone). Issac [12] found that the mean value of Rockwell hardness number is in inverse relation to the percentage water content of hardness test samples.

Another possible explanation for the reduction in surface hardness was reheating of the old resin (denture base) to cure the reline resin. This heat would lead to partial depolymerization, the heat stress cause water sorption of polymer to increase because of an extension of the distance between polymer chains. The water taken up in polymer acts as plasticizer and leads to decreased mechanical properties.[9, 19,20] The results also showed that the microwave curing method gave a higher surface hardness value (112.137±3.02 for Major and 113.175±1.54 for QD) than the water bath curing method for the control groups, without relining (109.85±3.93 for Major and 111.312±2.339 for QD). These results were in agreement with other authors.[21, 22]

Color Property Test: The results of this test, Table (2), and Fgure (3) showed that the denture base after relining despite the method of curing used, showed a significant increase at P = 0.05 in the optical density - absorbance - of the relined denture base. This could be attributed to the reheating of the old resin (denture base) to cure the new resin (reline resin), that could affect the dyes and pigments present in the material, also it could be attributed to the oxidation of un reacted double bonds of the un polymerized methyl methacrylate monomer. This un reacted monomer was present in the resin matrix because the degree of polymerization would never be 100% complete.[23, 24]

The results also revealed that there were no significant differences in the optical density (color property) for microwave, and water bath cured acrylic resin.

researches showed that the main two factors that have a major role in color property of acrylic resin are residual monomer content, and porosity caused by overheating. [23, 25]

In this study lower wattage (80 watts), longer curing cycle (30 minutes, and 15 minute per side followed by 1.5 minutes at high setting (500 watts) was used for microwave curing method. This curing cycle facilitated the exothermal heat to be dissipated quickly to the surrounding investing material, and the low wattage that was selected for the curing facilitates spreading of heat in gradual manner so that boiling point (100.3^{o}C) of the monomer was not reached. The 1.5 minutes at the high setting (500 watts) allowed removal of high percentage of residual monomer content in the acrylic resin, while the curing cycle for water bath method was selected in this study according to manufacturer's instructions. These results were in agreement with Hatim *et al*. [15]

Residual Monomer Test: The origin of inferior properties in denture base acrylic is more likely to be due to factors such as residual monomer, porosity, crazing, or residual stresses. [26] All acrylic resin denture bases contain a slight amount of residual monomer after processing. However, practically all traces of the residual monomer are extractable in water, or by saliva, and will disappear in few hours when worn by the patient, or immersed water [27].

The results of this study table (3) and figure (4) showed that, regardless of the group, residual monomer contents detected in the first 24hr. of analysis were higher than those found in the subsequent days and decreased with time. The decrease in the daily release of the monomer occurred as a result of the diffusion of the monomer into water and by continuous polymerization promoted by the active radicals found in the polymer chain. [17, 18, 28]

The residual monomer content of the heat cured denture base polymers was considerably low (less than 0.2%). This can be explained by the higher curing temperature, which can be as high as the Tg (glass transition temperature) of the matrix phase of the heat cured denture base polymer (97-100^{o}C). Above the Tg of the polymer, the monomers of the resins have a better ability to polymerize due to higher molecular chain motions, and neutralization of the immobilization of MMA in the glass polymer at higher temperatures. [29]

Table (4) and figure (5) showed that the double curing by water bath, or microwave curing method showed less amounts of residual monomer. This was in agreement with Urban *et al* [30] who stated that a further (soft-liner) heat cure cycle (2hr.at 100^{o}C) had a significant effect on reducing monomer concentrations. The study also showed that the microwave curing method had less amount of residual monomer than water bath curing method. This could be explained by that microwaves act only on the monomer, which decreases in the same proportion as the polymerization degree increases. Therefore, the same amount of energy is absorbed by less and less monomer, making the molecules increasingly active. This is important because a form of self regulation of the curing program takes place and leads to complete polymerization of the resin. [30]

Porosity Test: The result in this study showed that all the samples prepared in this study were free from porosities; this could be explained by the curing cycles used in the study.

In the water bath curing method, the manufacturer instructions were followed which allow gradual heating of the material for 30 min. from 70^{o}C to 100^{o}C, then boiling for another 30 min. In the microwave curing method, lower wattage (80watts) and longer curing cycle (30 minutes, 15 minutes per side) followed by 1.5 minutes at high setting (500 watts) was used. This curing cycle facilitated the exothermal heat to be dissipated quickly to the surrounding investing material, and the low wattage that was selected for the curing facilitated spreading of heat in gradual manner so that boiling point (100.3^{o}C) of the monomer was not reached. [15]. Also it can be assumed that, if a conventional resin denture base was ≤ 3mm thickness, it could be polymerized safely in a microwave oven,[32] s0o the samples in this study were free from porosities.

CONCLUSIONS

1-Surface hardness of denture base cured by microwave curing method was significantly higher than surface hardness of denture base cured by water bath curing method.

2-Relining, despite of the method of curing used for relining, decrease the surface hardness of the denture base.

3-There is no significant difference in the optical density (color property) of the denture base material cured by both curing methods. The optical density (color property) of the relined denture base was significantly higher than the control group (denture base without relining).

4- Microwave curing method resulted in lower amount of residual monomer than water bath curing method. Residual monomer contents detected in the first 24hr. of analysis were higher than those found in the subsequent days and decreased with time. Double curing leaded to a decrease in the amount of residual monomer in denture base material.

5-Both curing methods produced samples that are free from porosities.

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