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Effect of Microwave Disinfection on Transverse Strength and Hardness of Acrylic Resin Denture Base Materials

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الخلاصة

الاهداف:تهدف هذه الدراسة لتقييم تأثير التطهير بالموجات الدقيقة على قوة الانثناء وصلابة السطح لمواد قاعدة الطقم الاكريلية . المواد وطرق العمل:تم تحضير ١١٢ عينة لدراستها (٥٦ من قاعدة الطقم المتصلبة بطريقة الحمام المائي و٥٦تمثل قاعدة الطقم المتصلبة بطريقة الموجات الدقيقة)و بالأبعاد التالية: ٦٥ ±٠.٣ × ١٠ ± ٠.٠٣ × ٢.٥ ±٠.٠٣ملم لإختبار قوة الانثناء ٣٠ × ١٥ × ٠.٠٣ ± لإختبار صلابة السطوح تم تقسيم العينات الى٧ مجموعات.تم تحليل البيانات باستخدام تحليل التباين(الانوفا) واختبار دنكن. النتائج: دل تحليل البيانات المجموعة على وجود فرق معنوي في قوة الانثناء وصلابة السطوح بين المجاميع المدروسة الاستنتاجات:اظهرت الدراسة ان مادة قاعدة الطقم المتصلبة بطريقة الموجات الدقيقة أبدت بعد تعقيمها بالموجات الدقيقة نقصان في مقدار قوة الانثناء والصلابة إما قاعدة الطقم المتصلبة بطريقة الحمام المائي فأظهرت بعد التعقيم بالموجات الدقيقة زيادة في مقدار قوة الانثناء بينما الصلابة لم تظهر إي فرق معنوي.

ABSTRACT

Aims: To evaluate the effect of microwave disinfection on transverse strength and hardness of acrylic resin denture base materials. **Materials and methods:** The samples were 112 samples (56 heat cured acrylic resin and 56 microwave cured acrylic resin) they were prepared in dimensions of 65± 0.3x10±0.03x2.5 ±0.03 mm (length, width and thickness respectively) for transverse strength test and 30x15x3±0.03 mm (length, width and thickness respectively) for indentation hardness test. The samples were divided into seven disinfection groups; each one contain five samples which were (control, 900 W or 540W for 3min either inside glass flask containing 150 ml of distilled water)or along with glass flask containing 150 ml of distilled water or alone. The collected data were analyzed using analysis of variance (one way ANOVA) at $P \leq 0.05$ and Duncan's multiple range test. **Results:** the transverse strength of microwave acrylic resin samples were significantly decreased except samples that disinfected by 540 watt microwave energy for 3 minute with water inside microwave oven. The hardness number for heat cured acrylic denture base showed no significant differences compared to control group while hardness number of microwave acrylic resin were significantly decreased in relation to control group. **Conclusions:** Transverse strength of microwave acrylic resin that disinfected with microwave was decreased except at 540 watt for 3 minutes with water a side in microwave oven. While heat cured acrylic resin after microwave disinfection was significantly increased compared with the control sample. Rockwell hardness number for microwave acrylic resin significantly decrease in relation to control group; while for heat cured acrylic denture base showed no significancy comparing with the control group.

Key Words: microwave , disinfection, Transverse strength ,hardness.

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INTRODUCTION

Adequate maintenance of removable prostheses is needed for denture wearers to have an esthetic, odor free appliance and good oral health.[1] The microwave irradiation of dentures at a specified setting and exposure time is bactericidal and fungicidal.[2]Microwave irradiation for 5 minutes at 900 Watt is an effective method for disinfection against Staphylococus aureus and Pseduomonase aeruginosa.[3]

Microwave irradiation at 690 Watt for 6 minutes was used to disinfect denture resin bases.[4]

Two cycles of microwave sterilization (650W for 6 minutes) decreased the Vickers hardness number (VHN) of several types of acrylic resin denture teeth when

the specimens were not previously immersed in water but it did not affect the hardness when the specimens were previously immersed in water.[5]

Microwaving of acrylic resin specimens in domestic adjustable-wattage microwave oven result in significant increase in flexural strength means compared to the control.[6,7]

The aims of this study were to evaluate the effect of microwave disinfection on transverse strength and hardness of heat (water bath) and microwave cured acrylic resin denture base materials.

MATERIALS AND METHODS

Samples Preparation:

In this study, 112 samples (56 heat cured acrylic resin and 56 microwave cured acrylic resin) were prepared and divided as follows :

The transverse strength test, the dimensions were of 65 ± 0.3 x 10 ± 0.03 x 2.5 ± 0.03 mm (length, width and thickness, respectively). Twenty eight samples from heat cured acrylic resin (major base2/Italy) were prepared by adding 2.32 g powder for each ml of liquid according to manufacture instruction and 28 samples from microwave cured acrylic resin (Acron MC/Japan) were prepared by adding 2.25 gm of powder for each ml of liquid was used (according to manufacture instruction).

For indentation hardness test 28 samples from heat cured acrylic resin (major base2/ Italy) and 28 samples from microwave cured acrylic resin (Acron MC/Japan) materials were prepared on the dimensions of 30 x 15 x 3 ± 0.03 mm.[8]

Microwave Disinfection

The samples of transverse strength and indentation hardness tests were divided into the following disinfection groups:

Five control samples (un treated).

Five samples disinfected at 900 Watt for 3 min inside glass flask containing 150 ml of distilled water.[9]

Five samples disinfected at 900 Watt for 3 min along with glass flask containing 150 ml of distilled water.[10, 11]

Five samples disinfected at 900 Watt for 3 min alone.[10,12]

Five samples disinfected at 540 Watt for 3 min inside glass containing 150 ml of distilled water.

Five samples disinfected at 540 Watt for 3 min along with glass containing 150 ml of distilled water.

Five samples disinfected at 540 Watt for 3 min alone.

Physical Properties Tests

Transverse Strength Test:

Before testing, the samples were stored in a distilled water at 37°C for 48 hours. The test was applied by using 3 points bending on an Instron testing machine. The devise was supplied with a central loading plunger and two supports, with polished cylindrical surfaces of 3.2 mm in diameter and 50 mm between supports. The supports should be parallel to each other and perpendicular to the central line.[13] The tests were carried out with cross head speed of 5mm/min.

The test samples held at each end of the two supports, and the loading plunger placed mid way between the supports. The samples were deflected until fracture occurred .

The transverse strength were calculated using the following equation:

$$S=3PI/ 2bd2$$

S= transverse strength (Newton /mm2)
b= width of specimen (mm)
d= depth of specimen (mm)
I= distance between supports (mm)
P= maximum force exerted on specimen (Newton).[14]

Indentation Hardness Test:

The samples stored in a distilled water at 37°C for 48hours before testing. The samples surfaces were tested for hardness at five different locations then the mean was taken for each sample.

The test was done by using Rockwell hardness tester, equipped with an indenter in the form of round steel ball of 1/4 inch in diameter. The sample was first subjected to a fixed minor load of 60 kg (according to the instruction of the machine).

The collected data were analyzed using analysis of variance (one way ANOVA) at $P \leq 0.05$ and Duncan's multiple range test.

RESULTS

The Effect of Microwave on the Transverse Strength:

The mean, standard deviation of

transverse strength N/mm2 of the control and disinfected samples with different settings were shown in Table (1).

Table (1): Mean and Standard Deviation of Transverse Strength for Heat Cured and Microwave Cured Acrylic Denture Base Disinfected by Microwave with Different Microwave settings.

Disinfection settings	Mean ±SD (N/mm2)	Number
Microwave Cured Acrylic Resin		
C M	91.4850±4.00736	8
540 MA	83.0300±4.35475	8
540 MW	93.6250±6.15677	8
540 MI	83.0300±4.35475	8
900MA	76.4563±0.98038	8
900 MW	86.9662±1.12293	8
900MI	78.8975±5.20383	8
Heat Cured Acrylic Resin		
C H	72.8938±1.57137	8
540HA	91.2863±2.47197	8
540HW	82.7738±5.17202	8
540 HI	83.9438±7.26963	8
900HA	91.452 ±7.29434	8
900 HW	84.1025±8.64266	8
900HI	83.0650±4.77784	8

CM: control microwave cured resin; 540MA:540 watt for 3 minute microwave cured resin alone; 540MW:540 watt for 3 minute microwave cured resin with water; 540 MI: 540 watt for 3 minute microwave cured resin inside water;; 900MA: 900 watt for 3 minute microwave cured resin alone; 900MW: 900 watt for 3 minute microwave cured resin with water; 900MI: 900 watt for 3 minute microwave cured resin inside water; CH: control heat cured resin540HA:540 watt for 3 minute heat cured resin alone; 540HW:540 watt for 3 minute heat cured resin with water; 540 HI: 540 watt for 3 minute heat cured resin inside water;; 900HA: 900 watt for 3 minute heat cured resin alone; 900HW: 900 watt for 3 minute heat cured resin with water; 900HI: 900 watt for 3 minute heat cured resin inside water. SD: standard deviation; N/mm2: Newton/ millimeter square.

The analysis of variance (one way ANOVA) was illustrated in Tables (2) and (3) and confirmed that there were significant differences in transverse strength of tested groups at $P \leq 0.05$.

Table (2): Analysis of Variance (ANOVA) of Transverse Strength for Microwave Cured Acrylic Denture Base Disinfected by Microwave with Different Microwave Settings.

Source of variance	D f	Sum of Squares	Mean Square	F-value	*p*-value
Disinfection settings	6	1903.874	317.312	18.327	.000
Error	49	848.360	17.313		
Total	55	2752.234			

D f: degree of freedom, Significant at $p \leq 0.05$

Table (3): Analysis Of Variance (ANOVA) of Transverse Strength for Heat Cured Acrylic Denture Base Disinfected by Microwave with Different Microwave Settings.

Source of variance	Df	Sum of Squares	Mean Square	F-value	*p*-value
Disinfection settings	6	1801.173	300.196	8.796	.000
Error	49	1672.355	34.130		
Total	55	3473.529			

Df: degree of freedom, Significant at $p \leq 0.05$

Duncan's multiple range test of the transverse strength for control and microwave disinfected samples by different settings of microwave and heat curd acrylic resin was demonstrated in Figures (1) and (2) and revealed that the transverse strength for all microwave disinfection settings of microwave acrylic resin samples were significantly decreased except samples that disinfected by 540 watt microwave energy for 3 minute with water inside microwave oven .

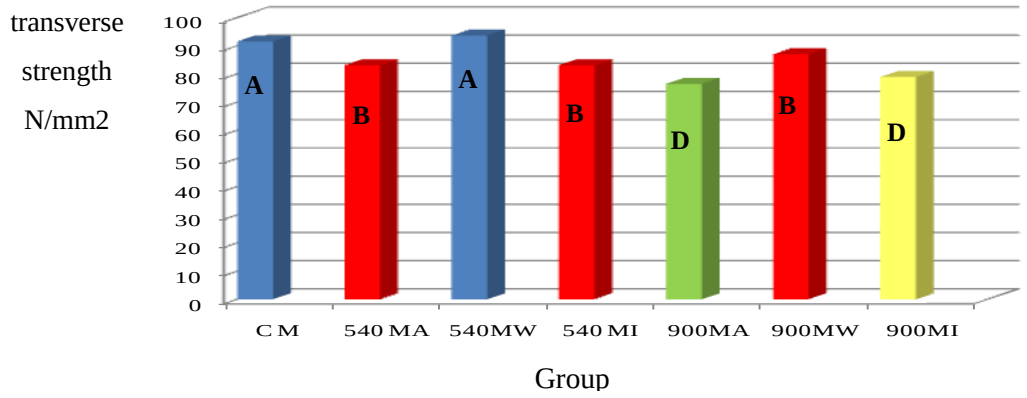

Figure (1): Mean of Transverse Strength for Microwave Cured Denture Base Acrylic Resin Disinfected by Different Microwave Settings.

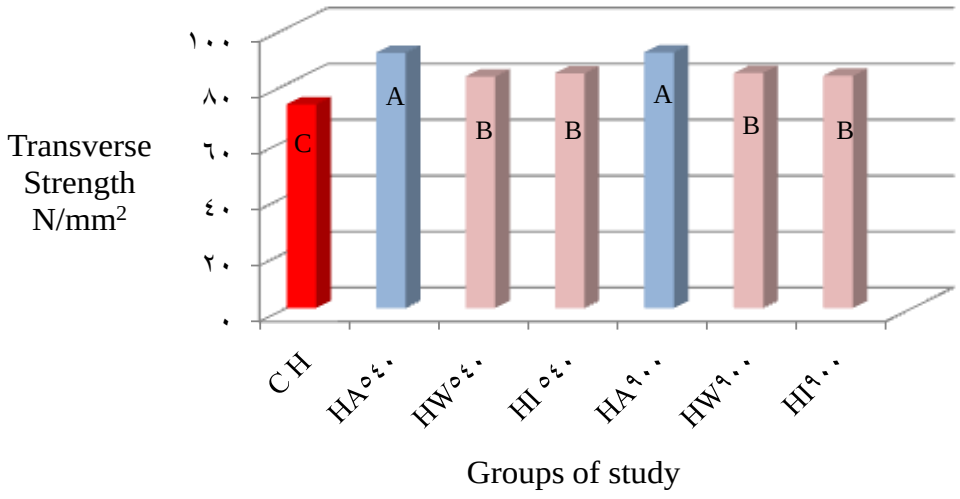

Figure (2): Mean of Transverse Strength for Heat Cured Denture Base Acrylic Resin Disinfected by Different Microwave Disinfection Settings.

CH: control heat cured resin540HA:540 watt for 3 minute heat cured resin alone; 540HW:540 watt for 3 minute heat cured resin with water; 540 HI: 540 watt for 3 minute heat cured resin inside water;; 900HA: 900 watt for 3 minute C cured resin alone; 900HW: 900 watt for 3 minute V cured resin with water; 900HI: 900 watt for 3 minute heat cured resin inside water.

Transverse strength of heat cured acrylic denture base disinfected by different microwave disinfection settings was significantly higher than that of microwave acrylic denture base.

The Effect of Microwave on the Surface Hardness:

The analysis of variance (ANOVA) for hardness number of microwave acrylic denture base was demonstrated in Table (4), which showed that there were a significant differences between tested samples at $p \leq 0.05$.

Table (4): Analysis of Variance (ANOVA) of Harness Number for Microwave Acrylic Denture Base Disinfected by Microwave with Different Microwave Settings

Source of variance	D f	Sum of Squares	Mean Square	F-value	*p*-value
Disinfection settings	6	1564.929	260.821	138.165	.000
Error	49	92.500	1.888		
Total	55	1657.429			

D f: degree of freedom, Significant at $p \leq 0.05$

Duncan's multiple range test of hardness number of microwave acrylic denture base disinfected by different microwave disinfection settings, was showed in Figure (3) and revealed that hardness number for all microwave acrylic resin disinfected samples by microwave disinfection settings were significantly decreased in relation to control group (104.938±1.5222 RHN), also the significant differences between different settings and group 2 setting had a highest value (94.125±.8763 RHN).

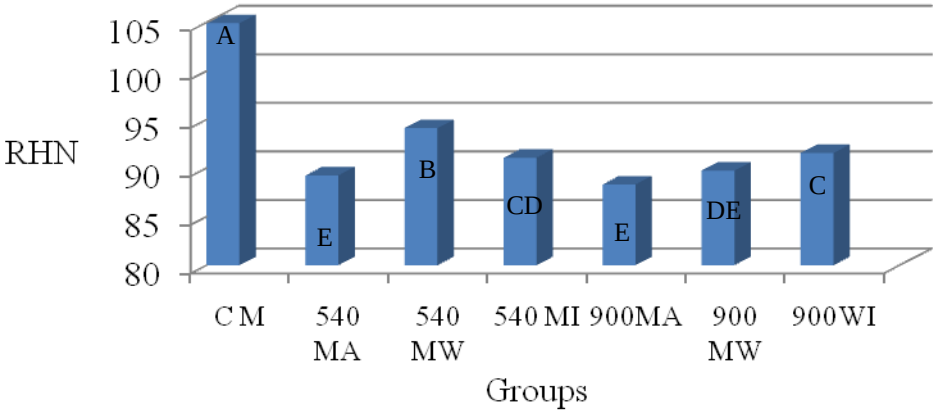

Figure (3): Mean of Rockwell Hardness Number for Microwave Cured Denture Base Acrylic Resin Disinfected by Different Microwave Disinfection Settings**.**

CM: control microwave cured resin; 540MA:540 watt for 3 minute microwave cured resin alone; 540MW:540 watt for 3 minute microwave cured resin with water; 540 MI: 540 watt for 3 minute microwave cured resin inside water;; 900MA: 900 watt for 3 minute microwave cured resin alone; 900MW: 900 watt for 3 minute microwave cured resin with water; 900MI: 900 watt for 3 minute microwave cured resin inside water.
RHN: Rockwell hardness number.

Analysis of variance (ANOVA) for hardness number for heat cured acrylic denture base was illustrated in Table (5), which confirmed that there were no significant differences between different disinfected groups and control group at $p \leq 0.05$.

Table (5): Analysis of Variance (ANOVA) of Harness Number for Heat Cured Acrylic Denture Base Disinfected by Microwave with Different Microwaves Settings.

Source of variance	D f	Sum of Squares	Mean Square	F-value	*p*-value
Disinfection settings	6	1337.527	222.921	1.455	.213
Error	49	7508.969	153.244		
Total	55	8846.496			

Df: degree of freedom, Significant at $p \leq 0.05$

DISCUSSION

Transverse Strength Test

Table (1) and Figure (1) revealed that the transverse strength for all microwave disinfection settings of microwave acrylic resin samples were significantly decreased except samples that disinfected by 540 watt microwave energy for 3 minute with water inside microwave oven .

The low powder / liquid ratio used would result in a high residual monomer left in the polymerized resin.[15]. For the microwave cured acrylic resin high powder liquid ratio was used (2.32 g powder for each ml of liquid according to manufacture instruction). So the polymerized microwave acrylic resin had lower residual monomer content compared to heat cured acrylic resin in which 2.25 gm of powder for each ml of liquid was used (according to manufacture instruction), and the specially designed acrylic for microwave curing exhibited significantly lower residual MMA leach compared with heat cured acrylic resin.[16] So, heating of the cured resin by microwave lead to partial de polymerization that result in extension of the distance between the polymer chain.[17]

Samples that disinfected by 540 watt microwave energy for 3 minutes with water inside microwave oven, it was likely that the presence of water in side the microwave oven prevent heat concentration on the sample [10] so the transverse strength of these samples has not been affected by microwave disinfection.

Heat cured acrylic resin Table (2) revealed that the transverse strength was significantly increased after microwave disinfection.

Microwave disinfection, results in residual monomer conversion into polymer. The residual monomer act by a plasticizing effect which effectively reduces inter chain forces. So that deformation can occur more easily under load, so, conversion of the residual monomer into polymer will improve the physical properties (18-20).

Other explanations may be the heat that occur during microwave disinfection, have promoted the diffusion of unreacted monomer molecules to the surface and their subsequent volatilization (21,22).

The increase in transverse strength after exposure to microwave irradiation is in agreement with Seo *et al*.,[6] and Polyzois *et al*.[23]

Surface Hardness Test

The analysis of variance (ANOVA) for hardness number of microwave cured acrylic denture base was demonstrated in Table (4), which showed that there were significant differences between tested samples at $p \leq 0.05$.

Figure (3) revealed that hardness number for all microwave acrylic resin disinfected samples by microwave disinfection settings were significantly decrease in relation to control group (104.938±1.5222 RHN). This result disagreed with Dixon et al.,[10] and Seo *et al*.[6]

This can be explained as follow: Heating of the cured resin by microwave lead to partial de polymerization that result in extension of distance between the polymer chain.[17]

Other clarification for this result is microwave cause vibration of the water molecules 2 to 3 billion/sec. Thus, producing friction that result in heating of water, high temperature plus movement of molecules probably cause water molecule that diffused more rapidly into polymer, water molecule acts as a plasticizer following diffusion in to polymer thus progressively relaxing polymer chain and subsequently

decrease hardness.[5]

Analysis of variance (ANOVA) for hardness number for heat cured acrylic denture base was illustrated in Table (5), which confirmed that there were no significant differences between different groups and control group at $p \leq 0.05$. This result was in line with Seo *et al*., but disagree with Dixon *et al*.[6,10]

In addition, the heat-polymerized acrylic resins should be maintained for at least one hour in terminal boiling to achieve the maximum monomer conversion.[24] Probably, the short boiling time adopted in this study resulted in lower degree of conversion, which might have been improved after microwave disinfection this result go on line with.[23]

Microwave disinfection, results in residual monomer conversion into polymer. The residual monomer act by a plasticizing effect which effectively reduces inter chain forces. So, that deformation could occur more easily under load.[18,19]

CONCLUSIONS

The transverse strength of microwave acrylic resin that disinfected with microwave was decreased except at 540 watt for 3 minutes with water a side in microwave oven, while for heat cured acrylic resin after microwave disinfection was significantly increased compared with the control.

The Rockwell hardness number for microwave acrylic resin disinfected by all microwave disinfection settings was significantly decrease in relation to control group. While for heat cured acrylic denture base disinfected by all microwave disinfection settings showed no significant differences to the control group .

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