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Effect of Microwave Disinfection on Hardness of Acrylic Base Denture Lining Material

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الخلاصة

الأهداف: تهدف الدراسة الى تقيم تأثير تكرار التطهير بالأمواج الدقيقة على صلابة مادة بطانة الطقم من نوع (vertex) المطبوخة بطريقة الحمام المائي والامواج الدقيقة. **المواد وطرائق العمل:** تم تحضير عشرين عينة بسمك (٤٥ ملم) وقطر(٢٥ ملم) من مادة بطانة الطقم من نوع (vertex) ثم لصقت العينات الى مادة قاعدة الطقم والتي بسمك (٢٥ ملم) وقطر (٥٠ ملم). ثم قسمت العينات الى مجموعتين رئيستين حسب طريقة الطبخ (الحمام المائي والامواج الدقيقة) ثم قسمت العينات كالاتي خمس عينات لكل طريقة طبخ كمجموعة سيطرة والعشرة الاخرى خمس عينات لكل طريقة طبخ للتطهير بالأمواج الدقيقة، وقد تم غمس العينات في(٢٠٠ مل) من الماء المقطر وعرضت لأشعة بمقدار (٤٥٠ واط / ٣ دقيقة) ثلاث مرات اسبوعيا لمدة شهر كامل (تم ١٢ مرة من التطهير بالأمواج الدقيقة) . تم قياس الصلابة باستخدام جهاز (Shore –A- hardness durometer). **النتائج:** اظهرت نتائج (t- test) ان هناك فرق معنوي بين مجاميع السيطرة وكذلك فرق معنوي بين التطهير لأول مرة بالأمواج الدقيقة والمطبوخة بالطريقتين. وبينت نتائج (ANOVA و Duncan)هناك فرق معنوي بالصلابة لمادة بطانة الطقم بمختلف اوقات التطهير بالأمواج الدقيقة وبالطريقتين وبمستوى معنوي عالي ($P \leq 0.01$). **الاستنتاجات:** تكرار التطهير بالأمواج الدقيقة لمادة بطانة الطقم من نوع (vertex) تفقد خاصية الصلابة بغض النظر عن طريقة الطبخ.

ABSTRACT

Aims: To evaluated the effect of the repeated microwave disinfection on hardness of vertex denture lining material cured by water bath and microwave. **Materials and Methods:** Twenty specimens were prepared 4.5 mm thickness × 25 mm in diameter from denture lining material (Vertex , Holland) adhered to specimen 2.5 mm thickness × 50 mm in diameter form a heat-cured acrylic resin (Vertex, Holland) and divided into two main groups according to the curing method (waterbath and microwave). The specimens were divided as following, ten specimens, five for each curing method as a control group. The other ten, five specimens for each curing method for microwave disinfection, specimens immersed in 200 ml of distilled water and irradiated with 540 Watt per 3 minute, three times weekly for one month started from the first time of microwave irradiation (microwave disinfection) to twelve times, tested for hardness by using Shore –A- hardness durometer. **Results:** The independent t-test revealed that, significant differences between control groups (specimens cured by water bath higher than that cured by microwave method), and significant differences between first time of disinfection by domestic microwave oven cured by two methods. The analysis of variance (ANOVA) and Duncan multiple range test confirmed there is a significant difference in hardness of denture lining material in different times of disinfection by domestic microwave oven for both curing methods at significant level ($P \leq 0.01$). **Conclusion:** The repeated disinfection by microwave irradiation deteriorated the vertex denture lining material regardless to the curing methods.

Key words: denture lining material, microwave disinfection

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INTRODUCTION

A denture may require relining of the intaglio surface as a result of tissue changes overtime.[1] Soft lining materials are widely used as a cushion on the fitting surface of dentures in the management of traumatized oral mucosa, bony undercuts, bruxism, ridge atrophy, and for congenital oral defects requiring obturation.[2-4] Where the denture-bearing tissues are less able to withstand masticatory stresses, soft denture liners provide an even distribution of the functional load on the denture-bearing area and avoid local stress concentrations.[5,6]

Acrylic resin-based resilient liner materials generally consist of polymers and monomers. The composition of the polymers and monomers is proprietary, but these materials generally include methacrylate polymers and copolymers, along with a liquid containing methacrylate monomer and plasticizers (ethyl alcohol and/or phthalate).[7]

The polymerization of denture base resin by microwave energy has been studied for more than three decades. The advantages of polymerizing denture base resin by microwave energy greatly reduced polymerization time, a cleaner method of processing, and a denture base with superior adaptation to the dental cast.[8,9] The clinical properties of resilient denture liners may be influenced by method of which they are polymerized.[10]

The dentures may become contaminated with microorganisms,[11] and cross-contamination of the prostheses may occur when the infected units are pumiced in dental laboratories.[12] Therefore, denture disinfection has been recommended to avoid cross contamination and prevent denture-related stomatitis.[11,13] The selection of a disinfection method should be based not only on its effectiveness against microorganisms, but also on its effects on the denture materials.[6] Microwave irradiation has been suggested as a method to disinfect denture bases,[14] Placing contaminated denture materials in water during microwave exposure is required to kill rather than inhibit yeast growth.[13,15,16]

MATERIALS AND METHODS

Twenty specimens were prepared form a heat-cured acrylic resin (Vertex, Holland) which divided into two main groups according to curing methods (water bath and microwave). The sample was prepared by disc of wax of 4.5 mm thickness and 25 mm in diameter adhered to a disc of Biostar material of 2.5 mm thickness and 50 mm in diameter by a using hot wax knife was put on a stone mould inside a metal flask.[17] The heat cured acrylic denture base material wax mixed according to the manufacturer instructions until it reached the dough stage, then the metal flask was opened and the Biostar disc was removed leaving the wax disc in it's place. The dough was packed in the stone mold instead of Biostar disc and a layer of selovent was applied between the acrylic and the wax, and the metal flask was closed, pressed under a hydraulic press according to the manufacturer instructions. After that the flask was re-opened, remove the piece of wax and the selovent layer. The denture lining material (vertex, Holland) was mixed according to the manufacturer instructions and put it in the stone mould instead of wax, then the flask was reclosed and pressed under a hydraulic press for fifteen minutes. The specimens of the first group were cured by water bath (according to its manufacturer instruction) and the specimens of the second group were cured by domestic microwave oven (LG, Korea) at 90 Watt for13 minutes + 500 watt for 90 seconds[18] by using fiberglass flask. The flash was trimmed with a scalpel. The specimens divided as following:- ten specimens, five for each curing method as a control groups. Another ten specimens, five for each curing method for microwave disinfection, specimens were immersed in 200 ml of distilled water[16] and irradiated with 540 Watt per 3 minute[19] three times weekly for one month [20] started form the first time of microwave irradiation (microwave disinfection) to twelve times, the specimens left on bench cooling then tested for hardness by using Shore –A- hardness durometer, The specimens stored in water at 37°C between exposure after each irradiation by microwave. The measurement was based on the penetration of an indentor into a specimen. Shore –A- durometer contain a scale reading from 30 to 100 shore –A- hardness units, Shore –A- durometer having tapered tip diameter 1/16 inch base and 1/32 inch at tip.

The specimens were placed on a bench, the shore-A- durometer (Figure 1), was held in a vertical position with the point of the indentor 5mm from the periphery of the specimen. The tip of the indentor was applied perpendicularly to the surface of the specimen, care was taken to ensure that the long axis of the indentor was perpendicular to the surface of the specimen in order to ensure accurate reading. Sufficient pressure was applied as rapidly as possible in order to obtain firm contact between the foot of the insetrument and the smooth surface of the specimen. Readings were taken after 1 second from the firm contact was achieved between the dureometer foot and the material under test.[21] Three measurements were recorded for each specimen at a time and the mean was calculated by using SPSS statically analysis version (11.5).

Figure (1): Testing procedure of Hardness Durometer

RESULTS

Table (1) demonstrated the descriptive statistic and independent T- test of hardness for denture lining material (DLM) cured by both methods (waterbath and microwave), revealed that there are significant differences between control groups (specimens cured by water bath higher than that cured by microwave method), and significant differences between first time of disinfection by microwave cured by two methods. The analysis of variance (one way ANOVA), is illustrated in table (2), and confirmed there is a significant difference in hardness of denture lining material in different times of disinfection by domestic microwave oven for both curing methods at significant level ($P \leq 0.01$).

Table (1): Descriptive Statistic and t- test of Hardness for Denture Lining Material Cured by Water Bath and Microwave After Repeated Disinfections by Microwave.

Duration	Methods	No.	Minimum	Maximum	Mean	Std. Dev	DF	T-test	*P*-Value
control	WB	5	35	38	36.88	0.509	8	2.649	0.029*
	MW	5	35	36.5	35.32	0.661			
First	WB	5	40.5	42	41.3	0.670	8	-2.708	0.027*
	MW	5	41.6	44	42.76	1.001			
Second	WB	5	43.2	44.6	43.88	0.521	8	1.253	0.245
	MW	5	42	45	43.2	1.095			
Third	WB	5	43	48	45.326	1.875	8	0.302	0.77
	MW	5	43	48	44.966	1.894			
Forth	WB	5	47	52	49.733	1.935	8	1.752	0.118
	MW	5	45.33	49	47.831	1.463			
Fifth	WB	5	50.333	53	51.499	1.178	8	-1.741	0.120
	MW	5	51	54	52.75	1.089			
Sixth	WB	5	53	56	54.7	1.095	8	-0.926	0.381
	MW	5	54.25	56	55.25	0.750			
Seventh	WB	5	50	61	57.7	4.41	8	-0.377	0.716
	MW	5	57	60	58.466	1.120			
Eighth	WB	5	58	61	59.4	1.341	8	-0.254	0.806
	MW	5	58	61	59.6	1.140			
Ninth	WB	5	60	64.5	61.9	2.79	8	-0.351	0.735
	MW	5	61	64	62.3	1.303			
Tenth	WB	5	62	65	63.4	1.341	8	-0.221	0.831
	MW	5	62	65	63.6	1.516			
Eleventh	WB	5	64.5	67	65.5	1.00	8	-0.475	0.648
	MW	5	64	68	65.9	1.596			
Twelfth	WB	5	66	68	66.8	0.836	8	-0.310	0.764
	MW	5	65.5	68	67	1.172			

WB: Waterbath, MW: Microwave, No.: Number, Std-Dev.: Stander Deviation, DF: Degree of Freedom, *significant difference at $P \leq 0.01$.

Table (2): Analysis of Variance (ANOVA) of Hardness for Denture Lining Materials Cured byWaterbath and Microwave Curing Methods

Methods		Sum of Squares	DF	Mean Squares	F	*P*-Value
Waterbath	Between Groups	5774.771	12	481.231	151.029	0.000*
	Within Groups	165.691	52	3.186		
	Total	5940.462	64			
Microwave	Between Groups	6145.618	12	512.135	324.043	0.000*
	Within Groups	82.183	52	1.580		
	Total	6227.801	64			

DF: Degree of Freedom, *significant difference at $P \leq 0.01$.

Figure (2,3) Duncan multiple range test revealed that there are significant difference between control and all others groups disinfectant by microwave oven for both curing methods, the twelve times of disinfection by microwave show higher effected on denture lining material for both curing methods.

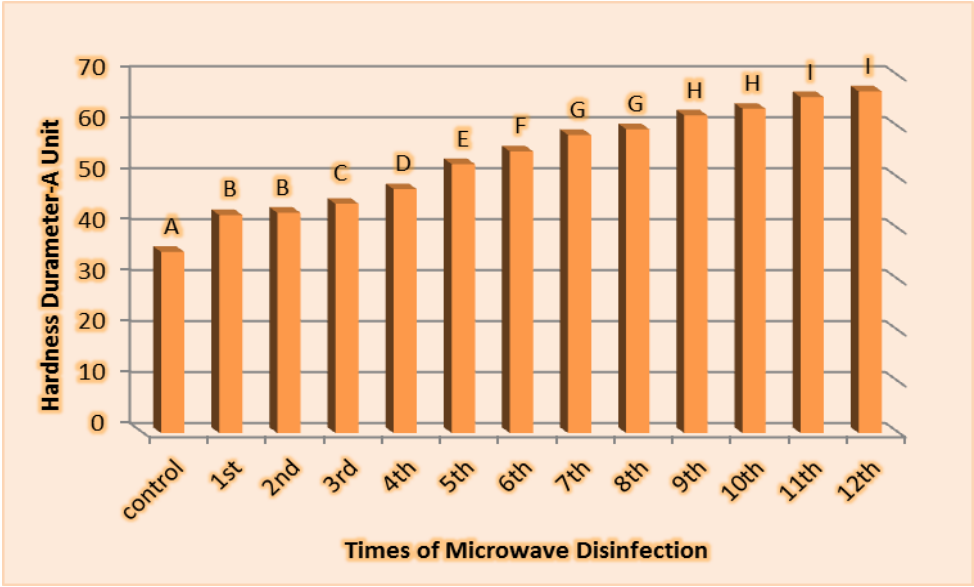

Figure (2): Duncan Multiple Range Test of Hardness of Vertex Denture Lining Material Cured by Microwave Oven After Times of Microwave Disinfection

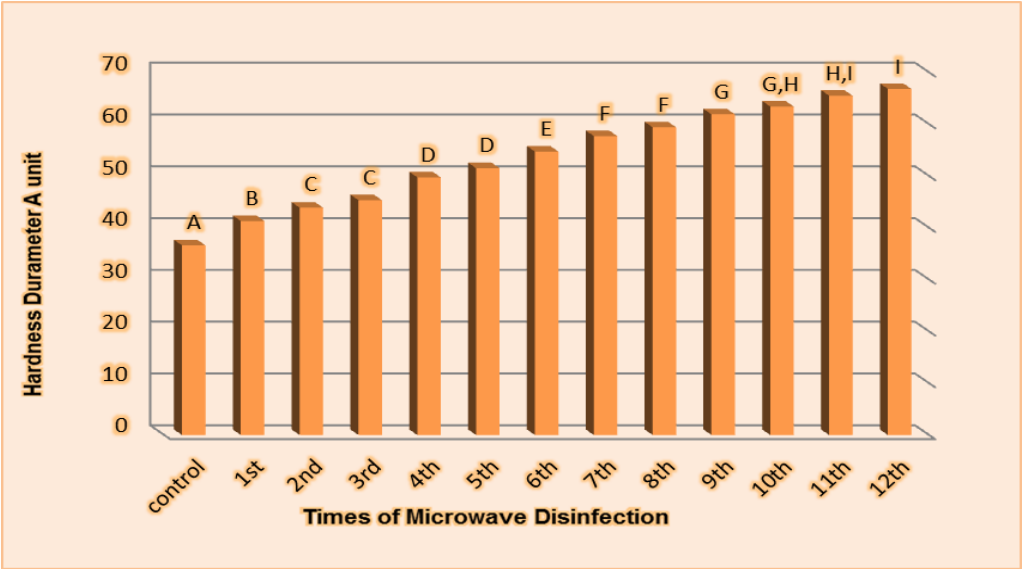

Figure (3): Duncan Multiple Range Test of Hardness of Vertex Denture Lining Material Cured by Waterbath After Times of Microwave Disinfection

DISCUSSION

From Table (1) t- test reveled there are significant differences between control groups(specimens cured by water bath higher than that cured by microwave method), and significant difference between the first time of disinfection by microwave cured by two methods. The polymerization method of soft lining materials may influence their physical properties.[22] According to some authors,[23-25] materials processed in the laboratory using conventional laboratory techniques may exhibit a higher degree of polymerization than materials not submitted to elevated temperatures and pressures, suggesting that these materials present better physical/mechanical properties.[26] The conversion of polymer using the microwave method (highly temperature reached during microwave irradiation) resulted in high level of residual monomer than in conventional water bath technique.[27]The hardness of denture lining material has been shown to be proportional to the residual monomer (act as aplastizier),[28] Microwave curing at low wattage for 30 minutes with an additional 1.5 minute at high wattage, rather than shorter times at higher wattage, increased the level of monomer conversion and produced a low level of residual monomer.[29] In this study using (90Watt for 13minutes) and (500 Watt for 1.5 minutes) may result in higher residual monomer content compared to the water bath curing method in which a 30 minutes terminal boil was used which result in higher residual monomer conversion. The magnitude of the effect is the of composition and degree of conversion of the material.

It is difficult to relate the findings of the present study to other investigations, because of the differences in specimen shape, dimension, type of denture base acrylic resin and resilient lining materials, and processing technique. From tables (1,2) and figure (2,3) reveled there are significant differences for both waterbath and microwave curing methods after repeated microwave disinfection, this agree with Machado *et al*,[30] they concluded that Microwave disinfection and immersion in distal water at 37°C for 30 days resulted in a small but significant increase in hardness of soft lining material, but disagree with Dixon *et al*,[13]evaluated the effect of 5 exposures to microwave irradiation as a disinfection method for dentures on the hardness of denture base and relining materials, the authors found that there are no significant differences for the resilient lining material and the denture base acrylic resin.

A significant increase in hardness was observed when the specimens were disinfected using microwave irradiation. One possible explanation is the temperature of

water in which the specimens were immersed during disinfection was increased by microwave irradiation.[15] When the specimens were heated the water started to boil after approximately 90 seconds of microwave disinfection. It is likely that the higher temperature of water may increase mobility of residual monomer molecules in the polymer matrix and the may lead to a further polymerization reaction[31] this will enhance the diffusion of remaining residual monomer molecules out of the resin, therefore, the increase in hardness observed in present investigation could be related to a decrease in residual monomer level as a result of further polymerization.[14,15] All specimens immersed in distal water during microwave irradiation, this can be assumed that the residual monomer that may have leached from the specimens during microwave irradiation lead to increased hardness.[32] The initial softness was due to the quantity of plasticizer and the residual monomer act as plasticizer in the material, since plasticizers are responsible for maintaining the softness of the acrylic resin based resilient liner materials. Leaching of plasticizers causes hardening of the acrylic resin based resilient liners.[33]

Release of plasticizers and other by-products of the polymerization reaction from resilient liners[34,35] has been suggested as the one reason for hardness changes. The hardness of the resilient lining materials increased after thermal cycling, which hardens the specimen and works against the effect of water uptake that would normally causes softening.[5]

Even though, the optimal hardness values of soft denture liners for clinical use have not been determined,[36] their shock-absorbing properties are known to increase with their softness, thus lower hardness is a desirable property for soft denture liners.[8] The maintenance of this property is a major problem during use of soft liners, since some of these materials are not stable in an aqueous environment, such as the oral cavity, and/or when immersed in disinfection solutions.[7,37]

CONCLUSION

The repeated disinfection by microwave irradiation for vertex denture lining material cured by (waterbath and microwave oven) significantly affect the hardness and deteriorated the vertex denture lining material regardless to the curing methods.

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