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Effectiveness of Microwave Sterilization on Surface Roughness of Polyvinyl Siloxane Impression Material

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Abstract

Aims: The study aimed to investigate the effect of sterilization by microwave irradiation at 640W on the surface roughness of polyvinyl siloxane. **Materials and methods:** 30 samples of addition silicone impression material with a thickness of 20mm and 3mm as diameter. The acrylic mold was used for the samples' fabrication. The samples were divided into six groups, each group had five specimens (C) control, (3MWD) Samples irradiated for 3minute in dry conditions, (6MWD) samples irradiated for 6minute in dry conditions, (3MWW) samples irradiated for 3minute in wet condition, (6MWW) samples irradiated for 6minute in wet condition and (CHX) samples immersed in chlorhexidine with 0.5% concentration for one hour. A profilometer (Talysurf 10, R.P.I. LTD, Metrology Division) was used for measuring surface roughness by taking the means of three points with the aid of a stylus. **Results:** There were statistical differences between the control group and the tested groups. Mann-Whitney test showed that only 3MWD had no statistical differences from the control group. **Conclusions:** Disinfection of polyvinyl siloxane using the microwave at 640W for 3 minutes is safe or recommended regarding its least effect on the surface roughness.

تأثير التعقيم بالموجات الدقيقة على خشونة السطح لمادة الطبعة السنية البولى فينال سيليكون

الملخص

الأهداف: تهدف الدراسة الى تقييم تأثير التعقيم بالموجات الدقيقة على خشونة سطح مادة الطبعة المصنعة من سيليكون إضافي التفاعل. **المواد وطرائق العمل:** تم تحضير 30 عينة من مادة السيليكون إضافي التفاعل (بولي فينال سيليكون) باستعمال قالب أكريليك. وكانت العينات بشكل أقراص ذات أبعاد 20*3 (القطر * السمك). قسمت العينات الى ست مجاميع تشمل: مجموعة السيطرة ,مجموعة التعقيم الجاف تحتوي على ثلاث دقائق وست دقائق تعقيم ,مجموعة التعقيم الرطب أيضا ثلاث وست دقائق والمجموعة الأخيرة التعقيم بالنقع لمدة ساعة بالكلورهكسيدين بنسبة 0.5%. **النتائج** : هناك تأثير واضح على خشونة السطح بعد تعرض مادة الطبعة السنية للتشعيع بالموجات الدقيقة ماعدا حالة التعقيم الجاف لمدة 3 دقائق لم تؤثر على خشونة السطح. **الاستنتاجات:** ان طريقة التعقيم الجاف لمدة 3 دقائق لمادة مادة السيليكون إضافي التفاعل (بولي فينال سيليكون)، هي الطريقة الموصى بها كونها الاقل تأثيرا على خشونة السطح.

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INTRODUCTION

Impression-making is a fundamental procedure in dental therapy that involves creating a replica of the oral cavity. Dental impressions that are exposed to blood and saliva from patients' mouths, which in turn serve as a source of infection to dental personnel who handle the impressions or casts for final restoration purposes [(1)].

Elastomeric impression materials were first introduced in dentistry in the 1950s. It should produce a replica of hard and soft tissues to obtain biologically, mechanically, functionally, and aesthetically acceptable restorations [(2)].

Addition silicone (vinyl polysiloxane) is obtained by the cross-linking polyaddition reaction of vinyl terminal polysiloxane polymers with methyl hydrogen silicone for mediation as a cross-re-action agent with the presence of platinum catalyst [(3)].

Surface roughness is defined as finely spaced surface imperfections whose height, width, and direction establish the predominant surface pattern. Surface irregularities are isolated imperfections, such as nodules, that are not characteristic of the entire surface area. Excessive roughness or irregularities on the outer surface of the casting necessitate additional finishing and polishing [(4)].

According to the ADA guidelines, all dental impressions should be thoroughly rinsed to remove blood, saliva, and food debris [(5)].

Microwave disinfection is an effective and versatile method, which is a quick, easy, and inexpensive method. This method can be easily performed by dentists, assistants, and technicians [(6)].

Few studies examine microwave irradiation as a disinfectant of polyvinyl siloxane, so the purpose of this study was to estimate the effect of microwave at 640W on the surface roughness of additional siloxane at different times and conditions.

MATERIALS AND METHODS

Approval of the present study was from the Scientific Research Committee / Department of Prosthodontics / College of Dentistry (UoM.Dent / DM. L.22/22).

Polyvinyl siloxane (light body, normal set: hydrophilic; HD + Zhermak) was used in this study. The tested sample dimensions were first designed using a computerized program (corel DRAW, 2020 Corel Corporation) and produced images. Image design was transferred to a computer-controlled Laser cutting machine (Boye Laser Application Technology Co., Ltd, China) used to cut the hole that represented the sample dimensions in hardened acrylic mold, two layers of hardened acrylic plates used as upper and lower covers. [(7,8)]

For the standardization of impression and standardization of loading applied, we used four G-clamps and four pins. The material was injected in holes of acrylic mold by the auto-mixing dispenser system

(BMG) and overfilled the holes with impression material. The third layer of mold is gradually and slowly put in to allow entrapped air and bubbles to reach the upper surface and get rid of by settling the third layer. Using the operator's hand to apply gentle pressure on the mold then finally four pins were fixed at each corner and four G-clamps were applied between them as seen in Figure (1) [8].

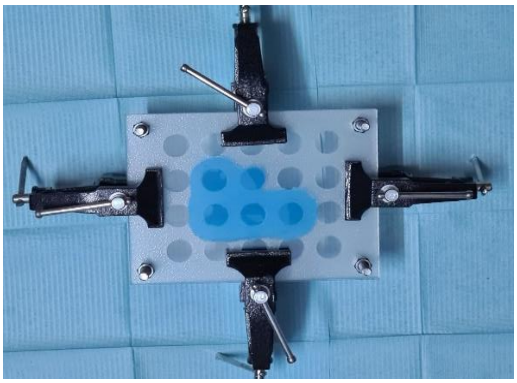

Figure (1): Acrylic mold of surface roughness samples with four pins and four G-clamps.

Preparation by additional silicone normal set which had 4minute of complete setting, duplication setting time, and gently separated the samples and sharp scalpel used to trim the excess material. Specimens were washed in tap water for 20 seconds. Plastic zipper bags are used for stored samples before disinfection and surface roughness measurements [9].

Surface roughness was measured on the disc-shaped specimens, thirty samples were prepared (five from each group), which had a diameter of 20 mm and a thickness of 3 mm [10].

Samples divided into six groups :(C) control group without disinfection, (3MWD) three minutes in dry condition of microwave at 640W, (6MWD) six minutes in dry condition inside microwave, (3MWW) three minutes in microwave and sample inside 200 ml of distilled water, (6MWW) six minutes in microwave inside 200ml of distal water and final group was (CHX) 200ml of chlorhexidine with 0.5% concentration immersion for one hour [11].

For the surface roughness test, three measurements of surface roughness were performed for each specimen and the mean value was calculated and used as the value for surface roughness of the specimen. The three points one at the midline point of the specimen, and two others at 5mm distance from the middle point [12].

The surface roughness was measured by using a profilometer (Talysurf 10, R.P.I. LTD., Metrology Division) Figure (2).

Figure (2): Profilometer for surface roughness measurements.

It may assess minor surface differences by sliding the diamond stylus across the specimens (specimens arranged in rows) laterally while in contact with the

surface. The surface roughness value was calculated as the mathematical average of the absolute values of the observed profile height of surface imperfections, as assessed from a mean line within a predetermined length of the specimen Figure (3). [13-16]

Figure (3): Samples arranged in profilometer.

The surface variations were calculated using the vertical displacement of the stylus. The stylus tip radius was 2.5µm, with a scan length range of 0.8mm.

RESULTS

Data collection and analysis assess the results utilized SPSS statistic software version 23 (IMB, USA).

Descriptive analysis included mean and standard deviation, Kruskal-Wllis analysis of variance, and Mann_whitney test used to examine the values and analyze the results. Table (1) Shows there were statistically significant differences between the control and microwave groups, also chlorhexidine group had increased surface roughness of addition siloxane except in three minutes in dry condition of microwave did not affect the surface roughness as shown in Table (2).

Table (1) illustrates a descriptive analysis of control and tested groups.

Table (1): Descriptive analysis and Kruskal-wallis test of surface roughness (Ra).

	Group	Mean	SD	K-W	Sig
Roughness test	Control	0.18	0.01	26.113	0.000**
	3 MWD	0.182	0.00836		
	3 MWW	0.124	0.005477		
	6 MWD	0.134	0.005477		
	6 MWW	0.114	0.013416		
	CHX	0.096	0.005477		

Table (2): Mann-Whitney test between control and microwaved group.

	Tested groups	Statistic	Sig
Roughness test (Ra)	C and 3MWD	11.000	0.740
	C and 6MWD	2.668	0,008**
	C and 3MWW	2.668	0.008**
	C and 6MWW	2.643	0.008**
	C and CHX	0.0001	0.008**

DISCUSSION

Microwave heating (MH) is the process of transforming microwave radiation's electromagnetic field energy into kinetic energy (heat) by interacting with the material's polar particles. Rotating dipoles (dipolar polarization), ionic conduction (ionic polarization), electronic polarization (atomic polarization), and interfacial polarization can all cause MH. [17]

A domestic microwave oven with a rotating table was used in this study because it was commonly available and achieved uniform distribution of irradiation. [18-20]

Microwave ovens increase the temperature of water-containing materials by vibrating the molecules 2 to 3 billion times per second. causing friction, which causes water to heat up after that, the water began to boil after about 2 minutes, and this supplied heating the object or sample uniformly.

Surface roughness results are shown in Table (1) and Figure (4) Kruskal-Wallis analysis of variance explained there were statistically significant differences between groups and at least there was one difference between the control group and tested groups. So, we used the Mann-Whitney test to explain the differences between the two groups and found which group differs from the control group.

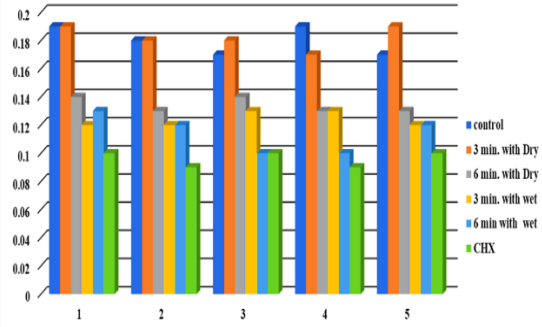

Figure 4: Mean rank of surface roughness test (Ra).

Table (2) illustrates that only 3MWD did not affect polyvinyl siloxane. Differences in roughness values as compared to the control group may be due to exposure to extreme temperatures, especially dry microwave heat, which could cause the surface to disintegrate. 3MWD may not have enough time for irradiation to cause disintegration of the surface. Chemical disinfectants may increase the surface roughness of impression material. Karaman *et al*., (2020) had the same findings as the present study when using sodium hypochlorite and quaternary ammonium-based disinfectant solution with four period time (1,2,3,30 min) and surface roughness increased with increased immersion time. [21, 22]

In this study, disc-shaped samples were obtained via contact with the shiny plastic surface and exposed directly to the CHX disinfectants, as there were no residues on their surfaces. Measuring the surface roughness was done within 24 hours after complete sterilization by microwave irradiation.

Kotha *et al*., (2017) evaluated chemical disinfection, autoclave sterilization, and microwave disinfection and effects on surface roughness. The results did not significantly affect the surface roughness of polyvinylsiloxane elastomeric impression materials by chemicals and autoclave. But microwave increased the roughness of elastomeric which was the same finding as the present study. [22]

Al-Kheraif, (2013) found that the surface roughness of a polyvinyl siloxane impression material after chemicals and autoclave disinfection processes had no significant difference between the control group and the tested groups, they noted a significant difference in the microwave

sterilization group also the same findings in the present study. [23]

CONCLUSION

Within the limitations of this in vitro study, the following conclusions were drawn: surface roughness of addition silicone affected by microwave irradiation at 640W, chlorhexidine affecting the surface roughness after one-hour immersion in 0.5%, three-minute dry condition (3MWD) of microwave did not affect surface roughness of addition siloxane.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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