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Temperature of Denture Base Resin under Different Protocols of Microwave Irradiation

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This *in vitro* study evaluated the temperature of dentures after different microwave irradiation protocols. Two complete dentures (one maxillary and one mandibular denture) were irradiated separately 4 times for each of the following 5 protocols: dentures immersed in water (G1- 6 min, G2- 3 min); dentures kept dry (G3- 6 min); dentures placed in the steam sterilizer (G4- 6 min, G5- 3 min). The final temperature of the dentures was gauged in a thin and in a thick area of each denture with an infrared thermometer. All groups presented an increase in the resin base temperature. The thin areas of the dentures underwent greater heating than the thick areas. There was no significant difference ($p>0.05$) between the final mean temperatures of dentures immersed in water for 6 (G1) and 3 min (G2). However, the final mean temperatures recorded in G1 and G2 exceeded 71°C and were significantly higher (<0.001) than the final mean temperatures recorded in the other groups. It may be concluded that denture base resins subjected to microwave irradiation immersed in water may be exposed to deleterious temperatures.

Key Words: denture, microwave, irradiation, resin, disinfection.

INTRODUCTION

There is a consensus that complete and removable partial dentures accumulate microorganisms, particularly bacteria and fungi, due to the porous surface of the acrylic resin, and this microbial colonization is one of the etiological factors of denture stomatitis. In addition to mechanical methods and chemical products for denture cleaning (1), microwaving dentures has been used as an inexpensive and effective method for denture disinfection. Several authors have demonstrated the efficiency of microwaves in this context (2-8). Some authors recommend microwave disinfection of the denture dry (3,4,7), while others indicate denture immersion in water during microwaving (6,8-14).

Several studies have measured the distortion of dentures after microwave irradiation (9,11,12,14). But the final temperature has never been determined before and the rise in the temperature may be the reason for the distortion of the dentures.

According to Anusavice (15), whenever dimensional alterations are inhibited, such as occurs in the polymerization process of heat-cured acrylic resins, the affected material contains internal stresses. If the stresses are relaxed, this may result in distortion of the material. The temperature for distortion by heat for polymethyl methacrylate acrylics ranges from 71° to 91°C (16). These values suggest the need for maintaining low temperature for denture repair and disinfection procedures.

This way, the aims of this study were to determine if different microwave irradiation protocols (dry and immersed in water) expose dentures to temperatures above 71°C and to compare these protocols with a new technique using a microwave steam sterilizer. The null hypothesis was that none of these protocols exposes the denture base resin to deleterious temperatures.

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MATERIAL AND METHODS

Two complete dentures, one maxillary and one mandibular, were fabricated of heat-activated acrylic resin in accordance with a previously described methodology (6,8). Two areas were selected and marked with an ink pen for gauging temperatures: one thin area and one thick area in each denture (Fig. 1).

A conventional microwave oven (Electrolux 1000 W; Electrolux, Manaus, AM, Brazil) was used for the tests. Four microwaving cycles at 700 W were performed for the maxillary and the mandibular dentures individually, for each of the 5 protocols: Groups 1 and 2: microwaving for 6 min (6,12) and 3 min (8,10,11,14), respectively, with dentures immersed in 200 mL of water; Group 3: microwaving for 6 min with dentures kept dry (3,4,7); Groups 4 and 5: microwaving for 6 min and 3 min, respectively, with dentures placed in a steam sterilizer (Microwave Baby Bottle Steam Sterilizer, KUKA, São Paulo, SP, Brazil).

A 5-min interval was given between the cycles. A digital spear-tipped thermometer (T361; Hikari HK, China) was used to gauge the water temperature, and an industrial infrared thermometer (TL 200; Mesco, São Paulo, SP, Brazil) was used for measuring the temperature of dentures at the end of the cycles.

Data were analyzed statistically by ANOVA and Tukey's test at 5% significance level.

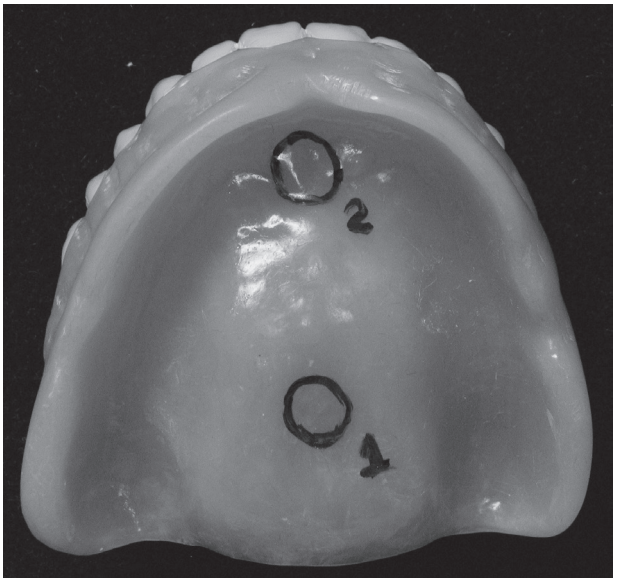

Figure 1. Complete denture with the thin area (1) and thick area (2) marked for recording the temperature.

RESULTS

Tables 1 and 2 present the final mean temperatures and standard deviation in the thin and thick areas of the complete maxillary and mandibular dentures respectively. There was an increase in the temperature of the complete dentures in all the tested groups after the microwave irradiation cycles. The thin areas of the dentures underwent significantly greater ($p<0.001$) heating than the thick areas.

Statistical analysis revealed that there was no significant difference ($p>0.05$) among the final mean temperatures of dentures immersed in water for 6 min (G1) and those immersed in water for 3 min (G2). However, the final mean temperatures observed in these groups exceeded 71°C and were significantly higher ($p<0.001$) than the other groups.

G3 and G5 presented the lowest ($p<0.001$) final mean temperatures both in the maxillary and in the mandibular dentures. There was no statistically significant difference ($p>0.05$) among the final mean temperature means of the mandibular dentures in G3, G4 and G5.

The water temperature surpassed 100°C in all groups and about 25% of the water evaporated during the process.

Table 1. Final temperature of the maxillary denture (°C).

Area	Group	Mean	Significant difference	p value
Thin area	G1	76.3 (0.7)	G3 x G4 x G5	<0.001*
	G2	72.6 (4.1)	G3 x G5	
	G3	55.2 (2.6)	G1 x G2 x G4	
	G4	70.4 (1.5)	G1 x G3 x G5	
	G5	57.8 (1.2)	G1 x G2 x G4	
Thick area	G1	76.7 (2.2)	G3 x G4 x G5	<0.001*
	G2	71.6 (1.7)	G3 x G4 x G5	
	G3	49.0 (7.8)	G1 x G2 x G5	
	G4	50.1 (8.9)	G1 x G2 x G5	
	G5	33.8 (2.9)	G1 x G2 x G3 x G4	

Statistically significant difference at 5% (ANOVA and Tukey's test).

DISCUSSION

The efficiency of microwaves against microorganisms has been extensively demonstrated (3,5,6,8), but there has been divergence among the results with respect to the effect of irradiation on the mechanical properties of denture resins. Some laboratory studies have demonstrated significant alteration in the internal adaptation (9), surface roughness (9), hardness (11) and dimensional stability (12). Nevertheless, other studies (10,13,14) have evaluated the same properties *in vitro* and considered the alterations to be not significant clinically. These results may be attributed to different irradiation protocols used in these studies, especially with reference to the ratio of time/irradiation power and whether the denture was immersed in water or not. The main protocols described in the literature were evaluated in the present study, which evaluated the temperature of the denture resin at the end of these irradiation cycles.

The temperature was significantly higher when dentures were immersed in water (G1 and G2). Thus, the null hypothesis was rejected. In G1, a mean temperature of 76°C was reached in the maxillary dentures. Even when the irradiation time was shortened to 3 min in G2, the mean temperatures continued to be above 72°C.

According to the literature (16), if the temperature of denture resins achieve values above 71°C, dimensional alterations occur by relaxation of the internal stresses induced in the polymerization process of heat-cured acrylics (15). This result may justify the alterations in the internal adaptation, hardness and dimensional stability found by some authors (9,11,12) who subjected test specimens to this microwave irradiation protocol.

In G4 and G5, the steam generated by boiling the water transferred less heat to the denture. It is likely that the steam is unable to heat the more internal and thicker areas of the acrylic resin, as occurred in G1 and G2. The results obtained in G3 (dry), G4 and G5 can be considered acceptable, since the values observed were below the temperature range considered critical. Clinical studies are still necessary to prove the efficiency of denture steam sterilization.

Some limitations of this study should be mentioned. Only 4 cycles were used for each protocol and the properties of denture materials were not evaluated after the cycles. Also, denture exposure to microwave radiation was not homogeneous because of the "heat" and "cold" zones inside the oven, so it is not possible to guarantee that the material was uniformly heated.

Within the limitations of this *in vitro* study, it may be concluded that the denture base resins subjected to microwave irradiation immersed in water may be exposed to deleterious temperatures.

Table 2. Final temperature of the mandibular denture (°C).

Area	Group	Mean (SD)	Significant difference	p value
Thin area	G1	73.3 (6.8)	G3 x G4 x G5	<0.001*
	G2	72.5 (5.4)	G3 x G4 x G5	
	G3	56.4 (4.9)	G1 x G2	
	G4	60.3 (2.3)	G1 x G2	
	G5	52.1 (2.2)	G1 x G2	
Thick area	G1	63.8 (5.1)	G3 x G4 x G5	<0.001*
	G2	63.4 (4.9)	G3 x G5	
	G3	53.7 (3.2)	G1 x G2	
	G4	54.2 (5.6)	G1	
	G5	51.7 (1.5)	G1 x G2	

Statistically significant difference at 5% (ANOVA and Tukey's test).

RESUMO

Este estudo *in vitro* avaliou a temperatura de próteses submetidas a diferentes protocolos de irradiação de microondas. Duas próteses totais (uma superior e outra inferior) foram irradiadas separadamente quatro vezes para cada um dos 5 protocolos que se seguem: prótese imersas em água (G1- 6 min, G2- 3 min); prótese a seco (G3-6 min); prótese no vapor (G4- 6 min, G5- 3 min). A temperatura final das próteses foi aferida em uma área fina e uma área espessa de cada prótese com um termômetro de infravermelho. Os resultados mostraram que todos os grupos sofreram aumento de temperatura. As áreas finas da prótese tiveram mais aumento da temperatura que as áreas espessas. Não houve uma diferença estatisticamente significante ($p>0,05$) entre a média da temperatura final das próteses imersas em água por 6 (G1) e 3 min (G2). Entretanto, a temperatura final média observada no G1 e G2 excederam 71° C e foram significativamente maiores ($p<0,001$) que a temperatura final média dos outros grupos. Pode-se concluir que as bases de prótese submetidas à irradiação por microondas imersas em água podem estar expostas a temperaturas deletérias.

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