Effect of Simulated Microwave Disinfection on the Mechanical Properties of Three Different Types of Denture Base Resins

ABSTRACT

Statement of problem: Disinfection of prostheses with chemical solutions has deleterious effects on dentures. The appropriate power setting of microwave for disinfection, without affecting denture base properties, is a controversy.

Purpose: To evaluate and compare the effect of simulated microwave disinfection at a recommended power setting on the mechanical properties of three denture base heat polymerized acrylic resins.

Material and Methods: Ninety rectangular specimens of each acrylic resin of 65mm × 10mm × 3 mm dimensions were divided into three groups. Group A (Trevalon), Group B (Trevalon- HI), Group C (Ivocap). In each group, thirty specimens were divided into three subgroups with ten specimens in each and they were submitted to MicroVickers hardness, flexural strength, and impact strength tests. In each subgroup, five specimens were tested before simulated microwave disinfection and they were considered as the control group. The remaining five were tested after simulated microwave disinfection and they were considered as the experimental group. Simulated microwave disinfection was done in a domestic microwave oven at 650 W for 5 minutes.

Results: The data were analyzed using One-way ANOVA and t-test. The mechanical properties of the three denture base resins were not altered after simulated microwave disinfection, as compared to those of the controls.

Conclusion: Microwave irradiation at 650 W for 5 min did not affect the mechanical properties of the three denture base resins. Domestic microwave oven, at the prescribed setting, can be used as an alternative method of disinfection for complete dentures without affecting their properties.

Keywords: Disinfection, Flexural strength, Impact strength, Hardness

INTRODUCTION

Prostheses which are contaminated with pathogenic microorganisms such as bacteria, fungi and viruses serve as a potential source of transmission of infection between patients and dental personnel [1]. Disinfection of these prostheses is necessary, to avoid cross contamination. Disinfection is the destruction of most but not necessarily all microorganisms [2].

Disinfection of prostheses with chemical solutions such as sodium hypochlorite, glutaraldehyde, and chlorine dioxide or alcoholic solutions has been recommended [3]. Immersion in chemical solutions may stain and whiten the plastic components of prostheses [4], due to the bleaching actions of the solutions on the denture base resin, corrosion of the frame work [5], or promotion of severe risk of cytotoxicity. To overcome this, microwave disinfection has been suggested as an alternative method for prosthesis disinfection. Webb et al., [6] reported that microwaving may be a method which is more effective for denture sterilization than denture soaking in sodium hypochlorite. Different time and power settings of microwave ovens have been proposed for denture disinfection. Though microwave disinfection at 604W for 10 min is bactericidal, an unacceptable dimensional stability has been observed in acrylic resin bases [7]. Overall, damage to denture base, surface roughness and poor adaptation were observed after a microwave disinfection at 690W for 6 minutes [8]. A microwave irradiation at 650W for 5 min promoted inactivation of S.aureus, P.aeruginosa, and spore forms of B.subtilis [5] and it is an effective method for acrylic resin disinfection. Though the bactericidal effect of microwave irradiation at 650W for 5 minutes has been proven, its effect on the mechanical properties of commonly used denture base acrylic resins, such as flexural strength, impact strength, hardness has not been tested. The purpose of this study was to evaluate the effect of simulated microwave disinfection at 650 W for 5 min on the hardness, impact strength, and flexural strength of three different types of denture base acrylic resins. The null hypothesis was that the simulated microwave disinfection did not affect the mechanical properties of the denture base acrylic resins at this recommended power setting.

MATERIAL AND METHODS

Ninety rectangular specimens of acrylic resins of 65mm X 10 mm x 3 mm dimensions (ISO Specification 1567) [9], were used in this study. These specimens were divided into three groups of 30 samples each. In group A, 30 specimens of conventional heat cure acrylic resin (Trevalon, Dentsply India Pvt Ltd), in group B, 30 specimens of High Impact acrylic resin (Trevalon- HI, Dentsply India Pvt Ltd) and in group C, 30 specimen of Injection moulded acrylic resin (Ivocap, Ivoclar Vivadent) were made. In each group, 30 specimens were divided into three subgroups and each was tested for Microvickers hardness, flexural strength and impact strength respectively. In each subgroup, 5 specimens were tested before simulated microwave disinfection and they served as the control group, and 5 specimens were tested after simulated microwave disinfection, which formed the experimental group.

To fabricate the rectangular acrylic specimen, a metal Die (Steel) was prepared to simulate the bar specimen of dimension, 66mm x 10.5mm x 3.5 mm [Table/Fig-1]. This die was invested in a conventional brass flask (Varsity flask; Jabbar and company, India) by using a type III dental stone (Goldstone; Asian chemicals, India) and it was prepared at a ratio of 30 mL water to 100 g powder. After the stone was set, the dies were removed and a cold mould seal (DPI heat cure cold mould seal; Dental products of India) was applied to the stone mould surface. This was allowed to dry at room temperature before it was packed.
Acrylic resin was mixed according to the manufacturer's instructions (Trevalon: 24g powder to 10 mL liquid; Trevalon-HI:25g-11 mL), it was packed in the respective mould in the dough stage, processed in an acrylizer (C-73A;Confident dental equipments LTD, India) at 74°C for eight hours and terminally boiled for one hour [10]. Specimens were bench cooled overnight before they were deflasked. The polymerized resin samples were retrieved from the mould and the excess resin were trimmed from all specimens with a bur (Dental future systems; Germany). For injection moulded resin specimens, predosed resin in capsules was mixed in a patented Cap Vibrator – thus producing a fully homogenous mix of the materials. Injection of the Ivocap denture material into the flask was done under 6 bar pressure and it was maintained during the subsequent polymerization. The design of the flask plus the thermal insulator enabled controlled polymerization from bottom to top. Each specimen was trimmed and finished with stone and sand paper. Polishing was done using Pumice slurry with a white bristle brush and a cloth buff. After final polishing, the specimens presented dimensions of 65.0 x 10.0 x 3.0 mm according to ISO 1567 specifications. All the samples were stored in water at 37°C for 24 hours before they were tested.

Each of the ten specimens in a sub-group was tested for MicroVickers hardness, flexural strength, and impact strength. In each subgroup, 5 specimens were immersed in 150 mL of distilled water in a glass container and they were placed in a domestic microwave oven (ONIDA power convection 21; Mirc electronics ltd; Mumbai) [Table/Fig-2] at 650 W for 5 min [5]. The remaining 5 specimens served as the controls. For flexural strength, the specimens were submitted to 3-point bending test [11], in a universal testing machine (FIE UTM) with a bur (Dental future systems; Germany). For injection moulded resin specimens, predosed resin in capsules was mixed in a patented Cap Vibrator – thus producing a fully homogenous mix of the materials. Injection of the Ivocap denture material into the flask was done under 6 bar pressure and it was maintained during the subsequent polymerization. The design of the flask plus the thermal insulator enabled controlled polymerization from bottom to top. Each specimen was trimmed and finished with stone and sand paper. Polishing was done using Pumice slurry with a white bristle brush and a cloth buff. After final polishing, the specimens presented dimensions of 65.0 x 10.0 x 3.0 mm according to ISO 1567 specifications. All the samples were stored in water at 37°C for 24 hours before they were tested.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Control Group</th>
<th>Experimental Group</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trevalon</td>
<td>156.62 ± 18.07</td>
<td>151.70 ± 19.79</td>
<td>0.85</td>
</tr>
<tr>
<td>Trevalon – HI</td>
<td>123.14 ± 22.60</td>
<td>124.96 ± 13.17</td>
<td>0.20</td>
</tr>
<tr>
<td>Ivocap</td>
<td>90.06 ± 10.88</td>
<td>96.90 ± 16.04</td>
<td>0.16</td>
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</tbody>
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</tr>
</thead>
<tbody>
<tr>
<td>Trevalon</td>
<td>20394.32 ± 0.00</td>
<td>20394.32 ± 0.00</td>
<td>0.07</td>
</tr>
<tr>
<td>Trevalon – HI</td>
<td>20552.65 ± 86.83</td>
<td>20456.72 ± 42.22</td>
<td>0.78</td>
</tr>
<tr>
<td>Ivocap</td>
<td>20394.32 ± 0.00</td>
<td>20394.32 ± 0.00</td>
<td>0.07</td>
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**DISCUSSION**

In this study, three types of denture base resins i.e. Trevalon, Trevalon-HI, and Ivocap were subjected to simulated microwave disinfections and they were studied for their flexural strengths, impact strengths and hardness and the same were compared before simulated microwave disinfection. The mechanical properties of any acrylic resin prosthesis should not be affected for reasonable microwave disinfection. The flexural strength, impact strength and hardness mechanical properties of the three denture base resins which were used in this study were not altered after simulated microwave disinfection. The null hypothesis in this study was accepted. Hence, microwave irradiation at 650W
for 5 minutes should be a reliable method for disinfection of acrylic resin prosthesis when the mechanical stability is considered.

Flexural strength is a simultaneous measurement of tensile, compressive and shear bond strengths [12]. This flexural strength represents the loading that occurs on the denture in the mouth during the masticatory process. In the present study, flexural strength values which were analyzed under non-disinfection (control) and simulated microwave-disinfection (experimental) conditions [Table/Fig-6], for Trevalon, Trevalon – HI, and Ivocap denture base resins did not differ significantly from each other. Despite statistical similarity among the three acrylic resins, a decrease in flexural strength values for Trevalon and Trevalon-HI was observed in this current study. Probably, this may be due to uptake of water during microwaving and consequent resin plasticization, which may have made it more flexible and resilient [13]. However, Ivocap denture base showed increased flexural strength values, which could be related to a reduction in the residual monomer level, which may have - a result of the higher degree of conversion [14]. Impact strength is a measure of energy absorbed by the material when it suffers sudden fracture [12]. In this present study, the simulated microwave disinfection did not affect the impact strength values for Trevalon, Trevalon – HI and Ivocap denture base resins [Table/ Fig-7]. It was assumed that the energy absorbed during the impact made by the tested materials was similar, probably because of the similar values of resilience, which may have produced statistically similar flexural strength values, even after simulated microwave disinfection [11]. Hardness test evaluates the material’s ability to withstand possibility of abrasion over time, during denture use [12]. In this present study, Micro Vickers hardness for the three denture base resins was not affected by simulated microwave disinfection. An increase in hardness values which was observed in the present study, could be related to a reduction in the monomer level, as a result of further polymerization caused by the microwave irradiation. It is well-known that an increase in temperature of storage media results in higher material diffusion rates [15].

Nepelenbroek et al., [16] demonstrated that when acrylic resin specimens contaminated with individual suspensions of three bacteria (P. aeruginosa, S. aureus, B. subtilis) were sterilized by microwave irradiation (6 minutes/650 W) it was observed that microwaving for 6 minutes at 650 W produced deleterious effects on some physical and mechanical properties of acrylic resin specimens. Thus, reduced microwave exposure times should be chosen, to produce consistent disinfection without any adverse effects on acrylic resins. Carlos et al., [13] analyzed the effect of microwave post polymerization on the flexural strengths of four auto polymerizing reline resins and 1 heat-polymerized resin (Lucitone 550) and they found a flexure strengths which were more than those of other hard reline resins after microwave post polymerization at 550 W for 3 minutes. Maria Agnese et al., [8] evaluated the cumulative effect of two protocols of microwave disinfection (Protocol 1: 690 W/6 min; Protocol 2: 345 W/6 min) on surface roughness (Ra) and base plate adaptation of two denture resins and they proved that protocol 2 was safer than protocol 1 for both resins. These studies also proved that lower power settings did not affect the properties of denture base resins.

Dovigo et al., [5] evaluated the effectiveness of microwave irradiation at 650W for 5 min on disinfection of complete dentures contaminated with S. aureus, P. aeruginosa and B. subtilis. The power setting used in this study did not affect the mechanical properties of the three denture base resins.

The limitations of this study were, that it has utilized only a specific shape of specimens and that complex shapes like complete dentures were not used in this study. Further studies with such complex shapes are necessary to confirm the results of this study. Although attempts were made to characterize the effect of microwave irradiation on the mechanical properties, further research is necessary, to evaluate as to whether the effect of repeated microwave disinfection may be deleterious to these properties of the denture base acrylic resins.

CONCLUSION
Simulated microwave disinfection did not affect the flexural strength, impact strength and hardness of the three denture base resins which were used in this study. Microwave disinfection method can be effectively used in the elimination of microbial pathogens from prosthetic devices.

REFERENCES