EFFECT OF DISINFECTANT SOLUTIONS ON A DENTURE BASE ACRYLIC RESIN

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ABSTRACT

The aim of this study was to evaluate the hardness, roughness and mass loss of an acrylic denture base resin after in vitro exposure to four disinfectant solutions. Forty specimens (Clássico, Brazil) were prepared and randomly assigned to 4 groups (n=10) according to the disinfectant solution: G1: control, stored in distilled water at 37°C; G2: 1% sodium hypochlorite; G3: 2% glutaraldehyde; G4: 4% chlorhexidine. G2 to G4 were immersed for 60 minutes in the disinfectant solution. Measurements were carried out both before and after immersion in the solution. The surface was analyzed with a surface roughness tester (Surfcorder SE 1700 KOZAKALAB), a microdurometer FM-700 (Future Tech) and a scanning electron microscope (DSM 962-ZEISS). Loss of mass was determined with a digital weighing scale. After disinfection procedures, values were analyzed statistically. The acrylic denture base resin may be vulnerable to surface changes after in vitro immersion in the disinfectant solutions studied.

Keywords*: Acrylic resins - disinfection - hardness - roughness.*

EFECTO DE SOLUCIONES DESINFECTANTES SOBRE PRÓTESIS CON BASE DE RESINAS ACRÍLICAS

RESUMEN

El objetivo de este estudio fue evaluar la microdureza, rugosidad y pérdida de masa de resinas acrílicas para base de dentadura después de su exposición a soluciones desinfectantes in vitro. Cuarenta especimenes de resina acrílica para base de dentadura (Clássico, Brasil) fueron confeccionados y asignados randomizadamente a 4 grupos (n=10) según la solución desinfectante: G1: control, almacenado en agua destilada a 37 °C; G2: 1% hipoclorito de sodio; G3: 2% Glutaraldehído; G4: 4% clorhexidina. Los especimenes fueron inmersos por 60 minutos en la solución correspondiente. Posteriormente, los especimenes fueron analizados antes y después de cada inmersión usando un rugosímetro (Surfcorder SE 1700 KOZAKALAB), un microdurómetro FM-700 (Future Tech), un microscopio Electrónico de Barrido (MEB) (DSM 962-ZEISS) y una escala digital. Después de los procedimientos de desinfección, los valores promedios obtenidos de cada análisis fueron evaluados estadísticamente. Las resinas para base de dentadura pueden ser vulnerables a los cambios de superficie cuando son inmersos en soluciones desinfectantes.

Palabras clave*: Resina Acrílica - desinfección - dureza - rugosidad.*

INTRODUCTION

The awareness for the need of infection control in cross-contamination during dentistry procedures for patients, dentists and laboratory technicians has increased due to the prevalence of some infectious diseases such as AIDS and Hepatitis B[1].

When dental prostheses are repaired or adjusted in dental practice, they are contaminated with bacteria, viruses, and fungi[2], due to inadequate disinfection of prostheses, the contamination of dental appliances and inadequate laboratory procedures before placing the prostheses in the mouth[1,3,4]. Potential sources of transmission of infectious diseases from patients to dental technicians include prostheses in contact with oral tissues, saliva and blood. When prostheses are removed from patients' mouths at various stages of trial and insertion, they may be contaminated by pathogenic organisms which can be transmitted through direct contact with the aerosol raised during trimming, finishing and polishing procedures[5].

The need to disinfect prostheses has resulted in the widespread search for disinfectant agents that are innocuous to the prosthesis surface. Various chemical agents are used in actual prosthesis disinfection, i.e. chlorine, iodophors, and aldehyde compounds[6]. Studies[7,8] included immersion in 2% alkaline glutaraldehyde, 0.5% and 1% sodium hypochlorite, 3% aqueous formaldehyde, hydrogen peroxide as alternative methods of dental prosthesis disinfection. In addition, 1% sodium hypochlorite, 4% chlorhexidine gluconate and 3.78% sodium perborate proved to be effective in reducing the number of microorganisms on dental prostheses[3,9]. Chlorine dioxide (Alcide LD) is effective in eliminating microorganisms from the internal and external surface of acrylic resin[10].

The importance of an infection control protocol in the dental laboratory is clear. Both the outer and inner surfaces of a dental prosthesis must be disinfected because they are both potential sources of contaminating microorganisms.Chau et al recommend 0.525% sodium hypochlorite solution for this kind of disinfection[11].

Several studies[12-19] demonstrated that various disinfectants affect the physical properties of denture base resins such as hardness[13,19] transverse strength[14,16], roughness[12,15] and deterioration on the surface of the denture resin[14]. The color stability of denture base resins can be significantly affected by disinfectant solutions such as glutaraldehyde, chlorhexidine, phenolic-based, alcohol-based and hypochlorite disinfectants[13].

The purpose of this study was to evaluate the hardness, roughness and mass loss of an acrylic denture base resin after *in vitro* exposure to three disinfectant solutions. A SEM analysis was also utilized to observe the surface topography.

Table 1: Description of the acrylic denture base resin used in this study.

Material	Manufacturer	Chemical composition
Thermally activated acrylic resin	Clássico, Artigos Odontológicos Ltda., São Paulo, Brazil	Methyl- Methacrylate polymer $CH_2C(CH_3)COOCH_3$

Table 2: Experimental groups, number (n) of samples and immersion time in the disinfectant solution.

Groups	Disinfectant solution	n	Immersion time
G1[a]	Distilled water	10	60 minutes
G2[a]	1% sodium hypochlorite	10	60 minutes
G3[a]	2% glutaraldehyde	10	60 minutes
G4[a]	4% chlorhexidine	10	60 minutes

[a]Thermally activated acrylic resin (*Clássico*, Brazil)

MATERIALS AND METHODS

Forty acrylic resin specimens (Table 1) were constructed using a metallic cylindrical device made of copper and aluminum alloy, 2mm in height and 10mm in diameter. A mould was prepared with condensation silicone, to dense, soft consistency (Silon2 APS, Dentsply Ind. and Comercio Ltda., Petrópolis, Brazil) and used to prepare twenty wax specimens.

These wax specimens were placed in flasks (DCL number 6®, Dentária Campineiro Ltda., Campinas, Brazil) as follows: dental stone type II was poured into the flask and 8 wax specimens were placed on the cast stone surface and covered with low-viscosity silicone (VIPI-SIL, VIPI., Pirassununga, São Paulo, Brazil). This impression material was placed in every retentive area of the wax specimens to optimize specimen preparation and removal.

The top part of the flask was completed with cast stone. After curing the cast stone and pressing, the flask was opened and wax specimens were removed, leaving the imprints in the silicone surface.

Heat-cured acrylic resin (Clássico, Artigos Odontológicos Ltda., São Paulo, Brazil) was prepared according to the manufacturer's recommendations, inserted in the plastic phase into the cast stone mold, and pressed gently and gradually in a hydraulic press to 1.25 t/pol^2.

An hour later, the flasks were transferred to a press with individual springs, and taken to the thermopolymerizing device[1] for polymerization at 72°C for 12 hours.

Following resin polymerization and cooling of the flasks at room temperature, the resin specimens were removed and finished with bars and through a sequence of SiC papers # 120, 400, 600, 800 and 1200, under coolant irrigation. Forty specimens were obtained and divided into 4 experimental groups according to the disinfectant solution (Table 2).

To analyze mass loss (ML), all the samples were weighed before and after exposure to a disinfectant solution on a digital weighing scale to the nearest 0.1 mg (Bioprecisa, Eletronic Balance, FA2104N, São Paulo, Brazil), recording W1: weight before exposure to each solution and W2: weight after the procedure. The percentage of mass loss (ML) for each sample was calculated with the following equation: [W1- W2 /W1] X 100[4, 5].

Surface roughness was measured using a Surf Corder SE 1700 KOZAKALAB roughness meter (Ra), running perpendicular to the direction of finishing procedure at 2mm from the surface, at a speed of 0.1 mm/s. Three measurements were made and the arithmetic mean was calculated for each sample.

The samples were submitted to a microhardness test using the Vickers indentation technique, with a microdurometer (FM-700, Future-Tech, Tokyo, Japan) (50gr load for 10s). Three indentations were made on each specimen, and the mean was taken as the microhardness value (HVN).

Scanning Electronic Microscopy (SEM, DSM 962, Zeiss, Oberkochen, Germany) was employed to analyze the topography of the samples at 200x and 2000x. The assessed surfaces were cleaned in distilled water in an ultrasonic device during 10 minutes. After this procedure, the samples were placed on the aluminum cylinders (*"stubs*") and gold coated for observation by SEM.

Statistical analysis of the numerical data was performed by Analysis of Variance (ANOVA), Tukey's test (95% reliability level) and Dunnet's Simultaneous Test.

Table 3: Means and standard deviations (SD) of mass loss (ML), microhardness (HV) and roughness (Ra).

		Mass Loss (ML)		Vickers hardness (HV)		Roughness (Ra)	
Groups	*n*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
G1	10	1.900	2.45	4.13	4.23	0.1189	0.28
G2	10	0.989	0.38	1.33	4.88	0.1389	0.21
G3	10	1.467	0.26	2.21	3.98	0.0092	0.18
G4	10	0.989	0.29	2.30	6.04	0.0478	0.16

Table 4: One-Way ANOVA for mass loss data obtained in experimental conditions.

Source	DF	SS	MS	F	P
Groups	2	1.36963	0.68481	6.85	0.0044<0.05
Error	24	2.39778	0.09991		
Total	26	3.76741			

Table 5: Comparison of averages, by Tukey's test for mass loss.

Groups	Means	Homogeneous Groups
G3	1.4667	A
G2	0.9889	B
G4	0.9889	B

RESULTS

An exploratory data analysis was performed to determine the most appropriate statistical test. The mean and standard deviation values of the mass loss (ML), microhardness (HV), and roughness (Ra) are listed in Table 3.

The data were analyzed, separately, by One-way ANOVA ($\alpha<0.05$) and Tukey's Test, considering three treatments and an additional treatment G1 (control group). Dunnet's test, a=0.05, was applied to compare the control mean with several treatment means.

Mass loss results showed no significant differences (Dunnet's Simultaneous Test) between G2, G3, G4 and G1 (control group).

For mass, One-Way ANOVA and Tukey's Test showed no significant differences between G2 and G4, but revealed statistically significant differences ($\alpha<0.05$) between G3 and groups 2 and 4. (Tables 4 and 5).

Hardness results showed no significant difference between G2, G3 and G4 and the control group (G1) with Dunnet's Simultaneous Test.

One-Way ANOVA of microhardness data revealed no significant difference between the experimental groups tested. G2, G3 and G4 showed similar behavior to the control group.

Dunnet's simultaneous *t* tests for roughness showed significant differences only between G2 and G1 (control group) but there was no difference between G2, G3 and G4.

One-way ANOVA revealed no significant difference in mean roughness between G2, G3 and G4. Surface topography after immersion in the disinfection solutions showed different patterns of changes (Fig.1-4). The irregular surface produced by 2% glutaraldehyde, 1% sodium hypochlorite, 4% chlorhexidine solution is characterized by the presence of pores and defects.

DISCUSSION

Reports in the literature using experimental testing protocols that would allow a comparison with this study are uncommon[1,3,9,10]. The purpose of immersing dental prostheses in a disinfectant solution is

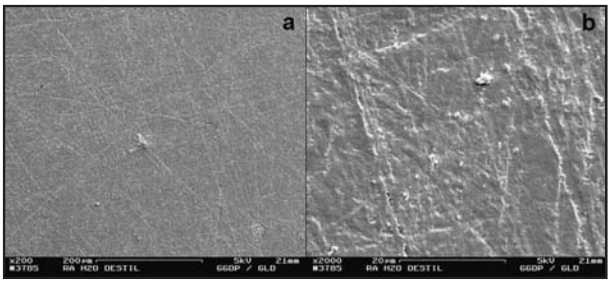

Fig. 1: Microphotography of the specimens immersed in distilled water (control group) magnified (a) 200x and (b) 2000x.

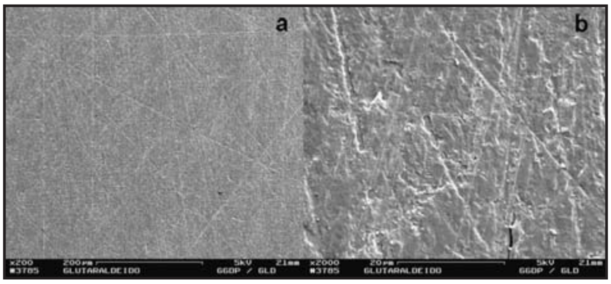

Fig. 2: Microphotography of the specimens immersed in 2% glutaraldehyde magnified (a) 200x and (b) 2000x..

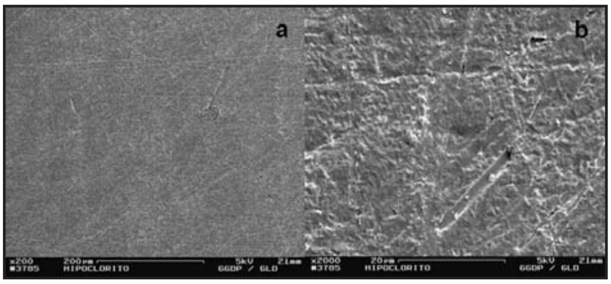

Fig. 3: Microphotography of the specimens immersed in 1% sodium hypochlorite magnified (a) 200x and (b) 2000x.

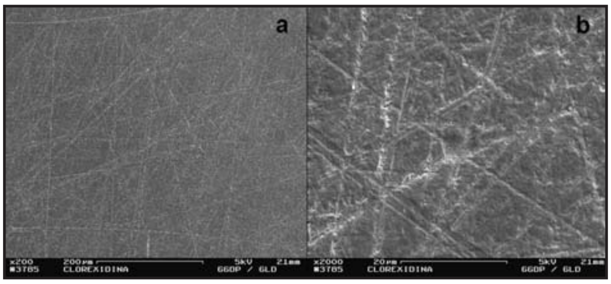

Fig. 4: Microphotography of the specimens immersed in 4% chlorhexidine magnified (a) 200x and (b) 2000x.

to inactivate infectious viruses and bacteria without damaging the dental prostheses. In this study, the disinfectant protocol was similar to others[9,12,17,19] that exposed resin acrylic samples to disinfectant solutions: 1% and 2% sodium hypochlorite, 4% chlorhexidine and 2% glutaraldehyde. Similarly to this study, others[1,3,5,9,12,13,19] evaluated the effects of disinfectant solutions on physical and mechanical properties of acrylic denture base resins, i.e. roughness, hardness and surface morphology[15 20,21].

Roughness affects the patient's comfort and prosthesis longevity. A smoother surface leads to better esthetic results and less biofilm retention[22]. Several authors emphasized that irregular surfaces increase retention of the microorganisms and may affect oral health[15,23-25]. In this study, roughness values increased in the samples that were disinfected with 1% sodium hypochlorite in comparison to the control group, but did not differ from the other groups. Garcia et al.[13] also observed surface changes in the samples that were submitted to disinfection and Machado et al.[15] (2011) showed that roughness of hard reline material was affected by immersion in sodium perborate.

Disinfectant agents may alter the surface of acrylic resins[13,15]. Current studies reveal that the samples immersed in sodium hypochlorite 1% showed a statistically significant increase in roughness compared to the control group. However, they did not differ from the other groups.

The microhardness of the acrylic resins used as denture base immersed in disinfectant solutions was also evaluated in the present study, similarly to other studies[1,9,13,20]. Hardness is the property of a material that gives it the ability to resist permanent deformation (bending, breaking or shape changes), when a load is applied[1].

The effect of disinfectant solutions on the microhardness of denture base after 60 minutes of immersion was observed. There was no statistically significant difference between the experimental groups and the control group, in keeping with other studies[12] that reported no significant effect on the surfaces of the samples after 24 hours of immersion in 2% glutaraldehyde, 0.5% chlorhexidine and alcohol solutions. The same results were obtained when the acrylic resins used for denture base were disinfected in solutions such as chlorhexidine 4%, sodium hypochlorite 1% and sodium perborate for 10 minutes[9]. In addition, some studies reported the immersion of denture base in 2% alkaline glutaraldehyde for 1 hour, which resulted in no significant effect on hardness values[1]. Twelve-hour immersion in disinfectant solutions did not affect some of the physical properties of resin specimens[19].

Surface morphology analyses showed changes in all the groups that were immersed in disinfectant solutions, mainly in samples immersed in sodium hypochlorite. Pore formation was observed in keeping with a study that used two glutaraldehyde disinfectant solutions, i.e. an alkaline solution and another alkaline solution with a phenolic buffer, and reported surface pitting and the formation of polymer beads after 10 minutes of exposure. When exposure time increased, the matrix phase seemed to dissolve slowly and more polymer beads were exposed[19].

Evaluation of mass loss of the acrylic resins following immersion for 1 hour in the disinfectant solutions glutaraldehyde 2%, chlorhexidine 4% and sodium hypochlorite 1%, for 1 hour revealed no statistically significant difference between the experimental and control groups. Nevertheless, samples immersed in glutaraldehyde solutions showed greater mass loss. Previous studies have reported mass loss following exposure of acrylic resins to disinfectant solutions. A decrease in weight would occur by water sorption. Signs of chemical attack were observed on the surface. These findings suggest that components of the disinfectant solution penetrate the resin base material and cause partial dissolution and softening of the surface[19]. Further studies will be necessary to examine how to minimize the damage of some kinds of disinfectant solutions on denture base acrylic resins.

CONCLUSIONS

The following conclusions can be drawn from this study:

1. Immersion of specimens in 1% sodium hypochlorite solution produced a significant increase in roughness.
2. No significant effect was observed on surface hardness of the tested specimens.
3. G3 mass loss values were higher than values in G2 and G4.
4. Qualitative evaluation by SEM showed varying degrees of surface change after immersion of the specimens in all the disinfectant solutions tested.

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