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Effect of Different Denture Base Cleansers on Surface Roughness of Heat Polymerised Acrylic Materials with Different Curing Process

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Efecto de diferentes limpiadores para dentaduras en la rugosidad de la superficie de acrílicos polimerizados por calor con diferentes procesos de curado

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ABSTRACT: Avoiding biofilm formation on dentures is associated with maintaining the surface properties of acrylic-based dentures. The aim of the study is to investigate the effects of two different cleaning agents (Corega and Klorhex 0.2% chlorhexidine gluconate) on surface roughness of the denture regarding efficacy of curing procedures. A total of sixty disc-shaped specimens were prepared with two different methods as long and short curing processes. The specimens were divided into subgroups according to the immersion solutions (distilled water, Corega tablet group and Klorhex 0.2% chlorhexidine gluconate group) (n=10). The samples were kept in a solution for 8 hours per day during a month. The average Ra₁ (before exposure to the cleanser agent) and Ra₂ (after exposure to the cleanser agent) of each sample was measured. A two-way ANOVA and post hoc Tukey test was used for statistical analysis. The solutions significantly increased the Ra values in both acrylic groups (p<0.001). While the effect of the distilled water group was significantly lower than Corega and Klorhex in the long-term curing group (p<0.05), no significant difference was found in the short-term curing group (p>0.05). The long-term curing time is highly effective in decreasing the surface roughness of the acrylic base material.

KEYWORDS: Surface roughness; Acrylic resin; Denture base material; Polymerization cycle; Denture cleanser; Dental materials.

RESUMEN: Evitar la formación de biopelículas en las prótesis dentales se asocia con el mantenimiento de las propiedades de la superficie de las prótesis de base acrílica. El objetivo del estudio es investigar los efectos de dos agentes de limpieza diferentes (Corega y Klorhex 0,2% gluconato de clorhexidina) en la rugosidad de la superficie de la dentadura postiza en cuanto a la eficacia de los procedimientos de curado. Se prepararon un total de sesenta muestras en forma de disco con dos métodos diferentes como procesos de curado largos y cortos. Las muestras se dividieron en subgrupos según las soluciones de inmersión (agua destilada, grupo de pastillas Corega y grupo de gluconato de clorhexidina al 0,2%) (n=10). Las muestras se mantuvieron en una solución durante 8 horas al día durante un mes. Se midió el promedio de Ra₁ (antes de la exposición al agente de limpieza) y Ra₂ (después de la exposición al agente de limpieza) de cada muestra. Para el análisis estadístico se utilizó un ANOVA de dos vías y una prueba post hoc de Tukey. Las soluciones aumentaron significativamente los valores de Ra en ambos grupos acrílicos (p<0,001). Mientras que el efecto del grupo de agua destilada fue significativamente menor que el de Corega y Klorhex en el grupo de curación a largo plazo (p<0,05), no se encontró ninguna diferencia significativa en el grupo de curación a corto plazo (p> 0,05). El tiempo de curado a largo plazo es muy eficaz para disminuir la rugosidad de la superficie del material de base acrílica.

PALABRAS CLAVE: Rugosidad de superficie; Resina acrílica; Material de base para dentaduras; Ciclo de polimerización; Limpiador de dentadura; Materiales dentales.

INTRODUCTION

The introduction of Poly(methyl methacrylate) (PMMA) was an important turning point in prosthetic dentistry because the material is convenient to use as a base for removable dentures owing to its properties of low water solubility, resistance to mastication forces, reparability and being economical (1). The curing process of PMMA is a reaction which requires an activator such as heat or light. So, the conversion of the methyl methacrylate (MMA) monomer to the PMMA polymer is accomplished (2,3). A polymerisation reaction with heat is a prominent method which can be carried out easily (4). The curing process for the method can be applied in a hot water bath as short-term or long-term time periods within the wide temperature range. It has been suggested that a terminal boiling stage at 100°C can improve the polymerisation reactions of PMMA, reducing residual MMA monomer content (5-7). This monomer

can cause detrimental effects on properties such as dimensional stability, water sorption, hardness, tensile strength, flexural strength, biocompatibility and even colour stability of PMMA (8,9). Also, it has been stated that polymerisation of time and heat emission can influence surface roughness (10). Surface roughness depends partly on the type of processing of denture base acrylic resin because high porosity can occur because of the short polymerisation cycles. An earlier study suggested that there should be a long polymerisation cycle to improve the surface integrity of acrylic resin (11). Similarly, Bayraktar *et al.* (12) stated that the amount of residual monomer can be reduced more effectively by a long time period (9 h at 70°C and 3 h at 100°C) instead of a short time period (20 min at 70°C and 22 min at 100°C). However, prosthetic treatments are supposed to be completed quickly, especially in public clinics. When time is limited, a short time curing process may be needed. Increased surface roughness because of the short

curing time can jeopardise the long-term success of acrylic dentures.

Maintaining hygiene of acrylic dentures is a primary issue to prevent oral and general health of individuals. Processed biofilm on dentures has been related to halitosis, denture stomatitis and even general systemic diseases such as aspiration pneumonia, infectious endocarditis, gastrointestinal infection and chronic obstructive pulmonary diseases (13). Mechanical and chemical methods are advised for denture cleaning routines. Brushing with a toothbrush and toothpaste, soap or cleansers under water is a well-known approach to eliminate plaque mechanically (14). Although this method mainly is employed by patients, it is not sufficient to clean undercut areas of dentures which easily harbour microorganisms. Additionally, elderly patients with poor motor coordination and disabled patients with poor manual ability and a lack of compliance may not properly clean the accumulated biofilm (15).

Chemical cleansers such as sodium hypochlorite solutions, denture cleansing tablets (sodium perborate) or mouthwashes like chlorhexidine gluconate are introduced to enhance hygiene of dentures (16). Chlorhexidine gluconate can inhibit candida yeasts on oral soft tissues and also the surface of dentures (17). Sodium perborate and chlorhexidine gluconate can be added to a denture hygiene routine. Ideally, these cleaning agents should not change the mechanical properties of denture base (14). But significant changes have been reported after immersion in cleansers. Ozyilmaz and Akin (15) stated that prolonged exposure to denture cleansers can increase surface roughness of PMMA surfaces. Durkan *et al.* (18) claimed that application of denture cleaners can cause decreased physical properties of dentures. Adverse effects of denture cleansers on various properties of

denture base resin have been investigated, but the effects of chlorhexidine gluconate have not been widely elucidated.

It is important determine how the properties of PMMA denture base change because of frequently used oral hygiene products. Previous studies revealed that short-term and long-term curing cycles are decisive factors altering the structure of PMMA (8,10,16). However, the effects of denture cleansers on PMMA prepared by either a short-term or long-term curing protocol have not been reported. The purpose of the study was to comparatively evaluate the effect of a denture base cleansing tablet and chlorhexidine gluconate on the surface roughness of heat polymerised acrylic material cured by short-term or long-term cycles. The null hypothesis tested was that no significant differences in the surface roughness of acrylic resin would be found after exposure to the different denture base cleansers.

MATERIALS AND METHODS

In the study, 60 specimens of heat cured denture base resin (Meliodent, Heraeus Kulzer, Hanau, Germany) were prepared for surface roughness testing. Disc-shaped wax patterns (10 mm in diameter and 2 mm thick) were produced using a stainless-steel mould according to ADA (19) Specification No. 12. After the dewaxing procedure, heat polymerised acrylic resin (Meliodent, Bayer Dental, UK) was prepared according to the manufacturer's instructions (in the ratio of 23.4 g powder to 10 mL liquid by weight) and put into the metal moulds. Two different curing procedures were applied. For the long-term curing process, after performing hydraulic pressure for 15 minutes, the specimens were polymerised in a hot water bath at 70°C for 9 hours followed by 100°C for 3 hours.

For the short-term curing process, under hydraulic pressure for 15 minutes was performed, then water bath polymerisation at 70°C for 20 minutes and then at 100°C for 22 minutes was completed.

After deflasking the cured specimens, excess acrylic was removed using a tungsten carbide bur. The specimens were wet ground using an automatic polishing machine (Grin PO 2 Vgrinder polisher; Metkon A.Ş. Bursa, Turkey) with silicon carbide paper of 120 grit. A digital Vernier caliper (Mitutoyo, Tokyo, Japan) was used to check the dimensions of all specimens, having an accuracy of ± 0.01 mm. Before testing procedures, the specimens were stored in distilled water at $37\pm 1^\circ\text{C}$ for a week to reduce the amount of residual monomer.

All specimens were assessed with a digital profilometer (Surftest SJ-210, Mitutoyo, USA) with the cut-off length being 0.8 mm before and after denture cleanser immersion procedures. The diamond stylus was moved across a length of 4 mm at 0.5 mm/s to the nearest 0.01 μm on the surface of specimen under a constant force of 4 mN. The surface roughness (μm) data obtained from arithmetic average of three times measured on manually approximating its centre point areas of the resin surface height of irregularities values. The surface roughness was recorded as Ra_1 (before exposure to the cleansing agent) and Ra_2 (after exposure to the cleansing agent).

Both long and short cycle curing groups were randomly further divided into three groups ($n=10$). The three specimen subgroups were randomly exposed to treatment with distilled water and two different chemical solutions (Corega or Klorhex). Distilled water was considered a control group, and Corega (sodium perborate, Block Drug Company, Jersey City, NJ, USA) and Klorhex (0.2% chlorhexidine gluconate, Drogosan Pharmaceutical Ind. And Trade Inc., Turkey) were defined as study groups. The Corega tablet was prepared in 100 ml of distilled water for the first study group. In

the second study group, 100 ml Klorhex was used. The immersion period was one month. The specimens of the control groups were immersed in distilled water throughout the experiment. The study specimens were immersed in Klorhex and Corega solutions for 8 hours to imitate the overnight denture hygiene care by the patient. During the test period, all specimens were cleaned with distilled water in an ultrasonic cleaner (Transsonic T700, Elma, Singen, Germany), and all cleanser solutions were renewed for every test procedure.

STATISTICAL ANALYSIS

A global significance level of 95% was considered for statistical analysis. The variable was tested for normal distribution using the Kolmogorov-Smirnov test ($p\geq 0.05$). Two-way variance analysis (ANOVA) was used for assessing significances for the effect of solutions on the surface roughness parameters (Ra values) of the specimens, and then Tukey's honest significant difference test was used for comparisons of the solutions. To compare Ra values, a paired sample t test was used in every group. Regression analysis was used to understand the correlation among acrylic curing procedures, solutions and surface roughness.

RESULTS

The mean first (Ra_1) and second (Ra_2) surface roughness values for each group are shown in Table 3. The results of the t test indicated that the curing process causes significantly higher Ra_1 values in the short-term group than detected Ra_1 values in the long-term group ($p<0.05$). The surface roughness values of all groups showed noticeable increases after immersion procedures ($p<0.05$) (Table 1).

The ANOVA test revealed that the Ra_2 surface roughness values of short-term polymerised specimens are not significant for cleansers ($p>0.05$) (Table 2). Conversely, analyses of Ra_2

values of long-term cured specimens were defined as significantly different for cleansers ($p < 0.05$) (Table 2). Further analysis with the post-hoc Tukey test showed significantly lower surface roughness for specimens immersed in distilled water compared to other groups ($p < 0.05$) (Table 3). There was no significant difference between the effects Klorhex and Corega on surface roughness ($p < 0.05$) (Table 3). Regression analysis revealed

that the correlation between polymerisation time and surface roughness was strong and reverse indicating a 52% rate ($r = 0.732$; $p = 0.00$ $p < 0.05$). The correlation between cleaners and surface roughness was not strong. In the short-term group, the correlation between cleaners and surface roughness was defined as 8% rate ($r = 0.087$, $p = 0.649$, $p > 0.05$). The correlation rate was 26% ($r = 0.510$, $p < 0.001$) in the long-term group.

Table 1. The comparison of surface roughness values between short and long curing time group. The comparison of surface roughness values intragroups.

Curing Time	Solution Groups	Ra1	Ra2	P value
Short	Distilled Water	1,01±0,32 ^a	1,14±0,33 ^b	<0.001
	Corega	1,04±0,29 ^a	1,41±0,30 ^b	<0.001
	Clorhex	0,99±0,29 ^a	1,21±0,24 ^b	<0.001
Long	Distilled Water	0,39±0,19 ^a	0,44±0,18 ^b	<0.001
	Corega	0,52±0,13 ^a	0,75±0,15 ^b	<0.001
	Clorhex	0,59±0,13 ^a	0,69±0,13 ^b	<0.001

Paired Sample t test, lower case letters show significant differences between Ra1 and Ra2 values of the same group.

Table 2. Two-way ANOVA of Ra2 values.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	4.135 ^a	5	.827	14.141	.000
Intercept	34.641	1	34.641	592.317	.000
Curing Process	3.907	1	3.907	66.798	.000
Cleanser	.103	2	.051	.880	.421
Curing Process*Cleanser	.125	2	.063	1.073	.349

a. R Squared=,567 (Adjusted R Squared=,527)

Table 3. The comparison of solution groups effects on Ra2 values among groups.

Curing Time	Solution Groups	Ra2	ANOVA p values	Tukey Test p values
Short	Distilled Water	1,14±0,33	0.124	-
	Corega	1,41±0,30		
	Clorhex	1,21±0,24		
Long	Distilled Water	0,44±0,18	<0.01	Distilled Water / Corega $p = 0.001^*$ Distilled Water / Clorhexidin $p = 0.004^*$ Corega/Clorhexidin $p = 0.724$
	Corega	0,75±0,15		
	Clorhex	0,69±0,13		

Two way- ANOVA and post hoc Tukey test* <0.005 indicates significant differences.

DISCUSSION

The surface of the acrylic base denture can influence the oral health profile of denture wearers. The acrylic base is in direct contact with oral tissues and the improper surface texture of the base facilitates the cumulation of microorganisms. The surface texture of acrylic dentures depends on many factors, such as residual methyl methacrylate monomer, polymerisation methods, polymerisation cycle, storage time in water and denture cleaning protocol (10,14). The roughness profile is highly associated with residual MMA monomer because of porosity (20). So, to reduce the amount of residual MMA monomer, the specimens were immersed in distilled water for a week before testing (12).

Short-time curing may cause significantly higher residual MMA monomer. Raising the curing time after heat polymerisation has been indicated for the conversion ability of monomers to polymerise, owing to counteraction of the immobilization of MMA (21). Measuring surface roughness which can be defined Ra values is a well-known method to determine surface textures in studies. In the current study, Ra values to evaluate the surface roughness were recorded and compared before and after exposure to cleaning agents. After immersion procedures, the surfaces of all specimens became significantly rougher than before. However, the increase in roughness did not exceed 2 μm , which is defined as a threshold value for microorganism colonisation (22,14).

According to our results, curing cycles have been more effective than cleaning agents for changing surface roughness. Surface roughness is probably related to short-term curing process (23). Considering the regression results, the effect of solutions remained weak. If the polymerisation cycle is executed properly, solutions should not reach a surface profile over the threshold value during a month. However, the effect of Klorhex and Corega cleansers on the surface of long-term cycle

polymerised specimens is significantly greater than that of the control group. Similarly, Garcia *et al.* (24) and Sharma *et al.* (25) stated that the use of a sodium perborate cleanser like Corega increases surface roughness. Barochia and Kamath (26) reported that the effects of effervescent denture cleansers on surface roughness of hard acrylic resin was not significant. Peracini *et al.* (27) showed that immersion in chemical solutions overnight did not alter surface roughness significantly after a week follow-up. Machado *et al.* stated that there was no difference between the surface roughness of heat-polymerised resin before disinfection and after 224 hours of total disinfection time (28). Conversely, Duyck *et al.* (29) and Pinto *et al.* (30) concluded that repeated immersions of chemical cleaners significantly increase surface roughness of acrylic base material. Schwindling *et al.* stated (31) that chlorhexidine can cause a slight increase in surface roughness, but it had no adverse effect on Ra. These different results can be related to various factors such as immersion duration, polymerisation process of PMMA and polishing methods of dentures. In this study, polymerisation process, solution effects and immersion duration factors have been searched. The specimens were immersed in solutions for eight hours during a month to imitate a night routine by denture wearers in the short term. A former study concluded that a short duration of immersion in cleaners did not significantly increase surface roughness, but extended immersion periods could lead to a higher surface roughness profile (32). So, further investigations to find out alterations in surface roughness, long-term effects of denture cleansers and other confounding factors are needed.

Within the limitations of the study, it can be concluded that the usage of Corega and Klorhex for a month can notably change the surface roughness of acrylic denture base in both curing protocol groups. However, the findings suggest that the curing protocol after polymerisation is important to improve surface stability of acrylic

material. Compared with short-term and long-term curing procedures, the effect of chemical cleaners was more clearly observed in the long-term cycle curing procedure specimens than the short-term curing procedure specimens because the short-term curing procedure was inherent to form roughness. Thus, the long-term cycle curing process should be preferred to decrease the surface roughness of the acrylic denture base.

CONFLICT OF INTEREST

The authors have no conflict of interest relevant to this article.

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