

The Effects of a Denture Cleanser on the Surface Roughness of Heat-Cured and Cold-Cured Acrylic Resins

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ABSTRACT

Objective: To evaluate the effects of one denture cleanser on the surface roughness of heat-cured and cold-cured acrylic resin materials.

Materials and Methods: Two acrylic resin materials (one heat cured and one cold cured) were used in this study. Twenty disk-shaped specimens (10 mm in diameter and 2 mm thick) were prepared from each resin, polished, and stored in water at 37°C for 48 hours. Disinfection methods included immersion in an alkaline peroxide effervescent denture cleanser for 5 minutes and then immersion in water at 37°C. The disinfection procedures were repeated 60 times in 6 days before submitting the specimens to surface roughness measurements. Control specimens (not disinfected) were kept in distilled water at 37°C for 6 days before undergoing surface roughness tests. Statistical analyses of data were conducted with an ANOVA and a Tukey *post hoc* test ($\alpha=0.05$).

Results: Cold-cured acrylic resin test specimens showed significantly ($p<0.001$) higher surface roughness values than the heat-cured resin specimens, regardless of immersion procedure. No significant change in surface roughness was observed in the heat-cured resin specimens after immersion in the denture cleanser (from 0.061 ± 0.013 to $0.063 \pm 0.08 \mu\text{m}$). A small, but significant ($p<0.01$), decrease in surface roughness value (from 0.120 ± 0.015 to $0.094 \pm 0.012 \mu\text{m}$) was observed in the cold-cured acrylic resin specimens.

Conclusion: Within the limitations of this *in vitro* study, cold-cured acrylic resin specimens exhibited significantly lower surface roughness values after immersion in the denture cleanser used. Heat-cured acrylic specimens were not affected by the immersion. (*Turkish J Orthod* 2013;26:92–97)

KEY WORDS: Acrylic Resin, Denture Cleanser, Surface Roughness

INTRODUCTION

Acrylic resins are widely used for removable orthodontic appliances and dental prosthesis in dentistry. Removable orthodontic appliances, important in orthodontic treatment, are used for space maintenance, tipping teeth, overbite reduction, retention, as a habit breaker, and to block movements.¹ In addition, removable dentures replace missing or lost natural teeth and their associated structures to a great extent. Most removable orthodontic appliances and dentures are made of a poly(methyl methacrylate) (PMMA) type of resin.² PMMA resins are manipulated using two different techniques: the addition (salt and pepper) technique, in which the polymer is saturated by its monomer, commonly used in orthodontics, and the

mass technique, in which powder and liquid are mixed together, used in prosthodontics.³

Removable acrylic appliances have to be worn for a prolonged period of time and are often exposed to intraoral conditions, which contribute to appliance-related problems such as dental caries, periodontal disease, and chronic atrophic candidiasis.⁴ The management of appliance-related infections is challenging, and infected appliances generally need to be disinfected.⁵ The daily intake of beverages such as coffee and tea as well as the use of some oral rinses

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tend to stain and discolor acrylic resins. Therefore, hygiene is very important for the maintenance and success of these appliances.

The removal of biofilm deposited on appliance surfaces is commonly accomplished by mechanical methods.^{6,7} Chemical cleansers are also used to effectively remove biofilms deposited in the surface irregularities of acrylic appliances, which might not be easily achieved by mechanical means. Several chemical cleansers have been suggested for the disinfection of acrylic appliances, and their efficacy in removing stains and reducing biofilm formation has been reported.⁸⁻¹⁰ However, some chemical agents used for denture cleaning are known to damage acrylic resins.¹¹⁻¹⁴

Surface roughness is determined by the presence of porosity and other irregularities on appliance surfaces and may offer a favorable niche to retain microbial plaque and stain.^{15,16} The surface roughness of acrylic resins used in dental practice is discussed frequently,¹⁶⁻¹⁹ and several studies have investigated the effects of denture cleansers on the physical and mechanical properties of denture resins.¹⁹⁻²⁵ However, few studies have investigated the influence of denture cleansers on cold-cured acrylic resin surfaces.^{1,26,27} Therefore, the aim of this study was to evaluate and compare the effects of one denture cleanser on the surface roughness of heat-cured and cold-cured acrylic resin materials used in orthodontics and prosthodontics. Our null hypothesis was that the surface roughness of heat- and cold-cured acrylic resins would not be affected after immersion in an alkaline peroxide effervescent denture cleanser.

MATERIALS AND METHODS

Two acrylic resin materials (one heat cured and one cold cured) were evaluated. The description, composition, and manufacturers of the acrylic resins and the denture cleanser used in this study are listed in Table 1.

The number of specimens needed to detect a meaningful difference between the mean surface roughness values of the groups in the present study was calculated based on a significance level of 0.05 and a power of 90%. The power analysis (NCSS 2007 and PASS 2008 Statistical Software; NCSS, Kaysville, UT, USA) showed that 10 samples from each group were required.

Specimen Preparation

To fabricate the 20 heat-cured acrylic resin test specimens, disk-shaped wax patterns (Modelling Wax;

Cavex, Haarlem, Holland) 10 mm in diameter and 2 mm in thickness were prepared by using a Teflon matrix. All the wax patterns were invested with a dental stone in metallic flasks. After the stone was set, the flask halves were separated, the wax was removed, and the stone mold was cleaned. The heat-cured acrylic resin was prepared by mass technique, packed, and pressed into the mold according to the manufacturer's instructions. Heat polymerization took place in water at 73°C for 90 minutes, followed by water at 94°C for 30 minutes. All flasks were allowed to cool to room temperature before being opened.

Twenty disk-shaped, cold-cured acrylic resin test specimens were also produced by using the same size (10 mm in diameter and 2 mm in thickness) Teflon matrixes. The cold-cured acrylic specimens were produced according to the manufacturer's recommendations by using the addition (salt and pepper) technique. First, a thin layer of the powder (polymer) was placed into the Teflon matrix, and then the liquid (monomer) was poured onto the powder layer, alternating with gentle pendulum movements. When a dry powder layer remained on the surface, the specimens were placed in a pressure pot and kept under 220 kPa (32 psi) in water at 45°C for 20 minutes for the polymerization.

After the polymerization, all the heat-cured and cold-cured specimens were immersed in distilled water at $37 \pm 1^\circ\text{C}$ for 48 hours for residual monomer elimination. Then, one surface of the specimens was polished by a standardized method, using progressively smoother aluminum oxide papers (grit numbers 280, 400, and 600).

The 20 heat-cured and 20 cold-cured acrylic resin specimens were each randomly divided into 2 groups. The heat-cured and cold-cured acrylic study groups ($n=10$) were immersed in an alkaline peroxide effervescent denture cleanser, and the heat-cured and cold-cured acrylic control groups ($n=10$) were immersed in distilled water. The alkaline peroxide effervescent cleanser was prepared according to the manufacturer's directions by adding one tablet to 200 ml of warm tap water ($40 \pm 2^\circ\text{C}$). The immersion time was 5 minutes for each cycle. Then, the specimens were removed from the container, thoroughly washed in running tap water, and dried with absorbent paper. Following the same procedure, 60 immersions (10 each day) were performed over a period of 6 days, simulating 1 year of cleaning by the patient. The specimens were kept in distilled water at $37 \pm 1^\circ\text{C}$ between the soaking cycles. The heat-cured and cold-cured acrylic resin control groups were immersed in

Table 1. Description and manufacturers of the materials used in this study^a

Material	Product Name	Composition	Manufacturer
Acrylic resins	Meliodent Orthocryl	PMMA denture base material Monomer: MMA (liquid) Polymer: PMMA (powder)	Bayer Dental, Newburg, Germany Dentaurum GmbH & Co. KG, Inspringen, Germany
Denture cleanser	Corega Tabs	Sodium carbonate, potassium caroate, citric acid, sodium carbonate peroxide, sodium bicarbonate, sodium benzoate, PEG-180, sodium lauryl sulfoacetate, subtilisin, PBP, aroma, CL44090	GlaxoSmithKline, Brentford, UK

^a MMA, methyl methacrylate; PMMA, poly(methyl methacrylate).

distilled water at $37 \pm 2^\circ\text{C}$ for 6 days, without the denture cleanser application.

Surface Roughness Test

The surface roughness of each specimen was determined by using a surface roughness tester (Surftest SJ-301; Mitutoyo Corp., Kawasaki, Japan) before and after the immersion procedures. The stylus tip of the drive unit moved across the specimen surface, and 3 lines were recorded, with a distance of 1 mm between each scanning line. The mean roughness value of the specimen ($R_a = \mu\text{m}$) was found by calculating the arithmetic mean of these 3 lines. The tracing length was 2.5 mm, and the cut-off value (λ_c) was 0.8 mm, at 0.5 mm/s. The resolution of the recorded data was 0.01 μm . The R_a values were used to assess surface roughness differences between the groups.

Statistical Analysis

The data were analyzed using a statistical software package program (SPSS ver. 12.0; SPSS Inc, Chicago, IL, USA). A Shapiro-Wilks test showed that the data were normally distributed in all groups, and an ANOVA and a Tukey honestly significant difference multiple-comparison test were used to determine the differences between the surface roughnesses of the groups ($p < 0.05$).

RESULTS

The descriptive statistics for the surface roughness values of the groups are given in Table 2, and mean values are diagrammatically shown in Figure 1. The cold-cured control group was found to have the highest mean surface roughness value ($0.120 \pm 0.015 \mu\text{m}$), followed by the cold-cured study group ($0.094 \pm 0.012 \mu\text{m}$). The heat-cured study group had a mean surface roughness of $0.063 \pm 0.008 \mu\text{m}$, and the heat-cured

control group had the lowest mean surface roughness value ($0.061 \pm 0.013 \mu\text{m}$).

The ANOVA results showed significant differences in the surface roughness between the 4 groups ($p < 0.001$). The results revealed that the surface roughness was significantly affected by the acrylic resin type ($p < 0.001$). Although the denture cleanser had no significant effect on the surface roughness of the heat-cured acrylic, it significantly decreased the surface roughness of the cold-cured acrylic resin ($p < 0.01$). The Tukey test results showed a significant difference between the cold-cured control group and the other 3 groups: cold-cured study ($p < 0.01$), heat-cured control ($p < 0.001$), and heat-cured study group ($p < 0.001$; Table 2).

DISCUSSION

Many research studies have supported the idea that the surface roughness of dental materials plays a critical role in bacterial biofilm accumulation and staining.* In this *in vitro* study, surface roughness was tested to observe if the alkaline peroxide effervescent denture cleanser could affect this property of heat-cured and cold-cured acrylic resins. It was found that immersion in denture cleanser did significantly influence the surface roughness of the cold-cured acrylic resin; however, the surface roughness of the heat-cured acrylic resin specimens did not significantly change after immersion in the effervescent denture cleanser (Table 2). Thus, our null hypothesis for the surface roughness of heat- and cold-cured acrylic resins was partly rejected.

The immersion time of 5 minutes was chosen because it was recommended by the manufacturer of the denture cleanser used in this study. Sixty immersions were applied to the specimens in the

* References 3, 4, 10, 11, 15, 16, 18, 19, 22, 24, 27–30.

Table 2. Comparison of mean surface roughness values of groups^a

Group	n	Mean (Ra)	SD	Range		p*
				Minimum	Maximum	
Heat-cured control	10	0.061	0.013	0.041	0.080	a
Heat-cured study	10	0.063	0.008	0.054	0.072	a
Cold-cured control	10	0.120	0.015	0.100	0.143	b
Cold-cured study	10	0.094	0.012	0.073	0.111	c

^a Ra, surface roughness value (in micrometers).

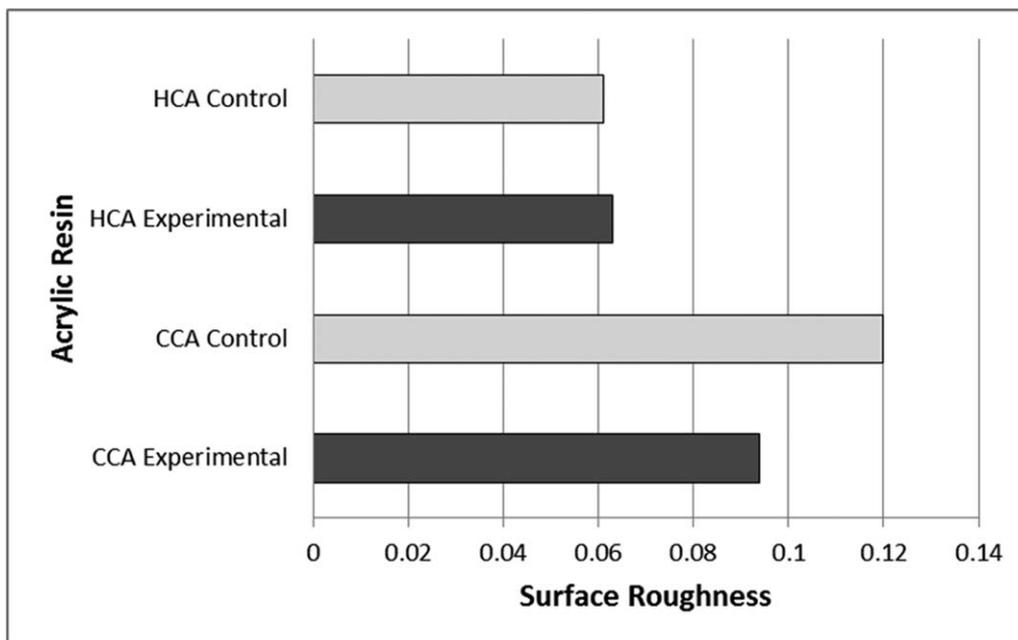
* Groups shown with same letters were not significantly different at the $p < 0.05$ level according to a Tukey honestly significant difference test.

study groups to simulate 1 year of soaking of removable orthodontic appliances and dentures in the cleansing solutions.

Biofilm accumulation affects the success rate of acrylic appliances, as well as oral health, and it has been reported that the rough surfaces of dental appliances accumulate and retain more dental plaque than smooth surfaces.³⁰ Ideally, a surface with the lowest possible roughness is recommended to thwart microorganism retention and prevent local infections and early appliance deterioration.²⁸ Denture cleaning by immersion in chemical solutions should not involve any physical, mechanical, or chemical change in the acrylic resin. The efficacies of chemical denture cleansers in dislodging food debris, biofilm, and tobacco stains from prosthesis surfaces have been previously reported.^{2,9,15,31} Effervescent denture cleanser tablets are efficient in removing biofilms and

stains.³¹ The decontamination process of chemical agents may result in alterations of surface morphology and changes in flexural strength.¹⁶⁻³² Because the surface roughness value of the cold-cured acrylic resin decreased after immersion in the denture cleanser in this study, this phenomenon was supported.

The heat-cured acrylic resin groups (control and study) had less-rough surfaces than the cold-cured acrylic resin groups in this study (Table 2). This result is in accordance with the study³³ that reported that the heat processing of acrylic resins generated less-rough surfaces than the other polymerization techniques. The present study also deals with the question regarding the difference in surface roughness of the 2 types of acrylic resins. It is a common belief that heat application to acrylic resins during polymerization could increase the polymeric chain formation, thus reducing the level of residual

**Figure 1.** Mean surface roughness of the groups.

monomers.^{1,33} This effect, in turn, could result in heat-cured resin surfaces that are less porous and less rough than those of cold-cured resins.

In this *in vitro* study, there was no significant difference between the surface roughnesses of the control and study groups of the heat-cured acrylic resin. In other words, the denture cleanser used in this study had almost no effect on the surface roughness of heat-cured acrylic resin. This part of the study confirms the results of a previous study¹⁶ that investigated the effect of the same denture cleanser on heat-cured acrylic resin and reported no significant changes in the surface roughness values, even though the heat-cured acrylic resins tested varied. However, in the present study, a statistically significant difference in surface roughness was found between the control and study groups of the cold-cured acrylic resin test specimens. This difference between the control and study groups may be explained by water absorption and the residual monomer level of the PMMA resin.³⁴ Because PMMA exhibits long-term water sorption due to water molecule diffusion, probably spreading out the macromolecules, the surfaces of cold-cured removable orthodontic appliances act as a sponge, with several porosities.²⁷ In addition, acrylic resins absorb water slowly over a period of time, primarily because of the polar properties of the resin molecules.³⁵ Immersion in water enables water molecules to penetrate into the areas between the polymer chains, remain there, and act like wedges between these chains.³⁶ It has been reported that the high equilibrium uptake of water could soften an acrylic resin, as the absorbed water can act as an acrylate plasticizer and reduce the strength of the material.^{37,38} On the other hand, it has been proven that there is a relationship between residual monomer and water sorption. If residual monomer is present, less monomer conversion occurs and may result in increasing sorption and solubility.³⁹

In vitro studies are limited in their ability to simulate clinical conditions. In this study, the effects of the denture cleanser on biofilm deposition and bacterial adhesion were not evaluated under *in vivo* conditions. In this respect, the effects of denture cleansers on the surface roughness and bacterial adhesion of acrylic materials under *in vivo* conditions may differ from those of *in vitro* studies. In addition, further studies are needed to evaluate resin roughness and other physical effects of different chemical disinfectants on cold-cured acrylic resins. Choice of the appropriate acrylic material and disinfection procedure combination might provide more desirable surface properties of dental appliances for

orthodontic patients. Additional clinical (*in vivo*) studies are also necessary to confirm the long-term behavior of surface properties of acrylic resin appliances after variable disinfection techniques.

CONCLUSIONS

According to the results of this *in vitro* study, the following conclusions were drawn:

- Heat-cured acrylic resin materials did not reveal any significant surface changes after immersion in an effervescent tablet cleanser. It could be stated that the denture cleanser has no negative effect on the surface roughness of heat-cured acrylic resins.
- After immersion in the denture cleanser, the surface roughness values of cold-cured acrylic resins significantly increased. This result might be related to residual monomer and water absorption of cold-cured acrylic resins.
- Because of the higher surface roughness values of the cold-cured acrylic resins, orthodontic patients must pay more attention to the hygiene of their appliances.

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