

Effect of Chlorhexidine and Castor Oil on Surface Roughness of Heat-Cured Acrylic Resin Denture Base

Elkana Lumban Gaol, Putri Welda Utami Ritonga

Department of Prosthodontia, Faculty of Dentistry, Universitas Sumatra Utara, Medan, Sumatera Utara, Indonesia

*Corresponding Author: elkanalumbangaol@gmail.com

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ORCID : Gael EL ([0000-0003-0982-3145](https://orcid.org/0000-0003-0982-3145)); Ritonga PWU ([0000-0001-7952-1674](https://orcid.org/0000-0001-7952-1674))
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ABSTRACT

Background: Heat-cured acrylic resin is the acrylic resin most often used to make denture bases. In its use as a denture base, heat-cured acrylic resin requires a disinfectant to clean it from contamination by microorganisms. Still, it does not affect other properties of the heat-cured acrylic resin. **Objective:** This study aimed to determine the effect of heat-cured acrylic resin denture base disinfection with chlorhexidine and castor oil on surface roughness. **Materials and Methods:** This research is laboratory experimental with 30 bar-shaped (50x20x3mm) heat-cured acrylic resin-denture base specimens samples were divided into two groups, with chlorhexidine 0.2% simulated 3, 4, and 5 years and with castor oil 10% affected 3, 4, and 5 years. The surface roughness was tested using the Roughness tester TR200. Data were analyzed using univariate statistics and an independent t-test ($\alpha = 0.05$). **Results:** The research showed no significant effect in the disinfection of heat-cured acrylic resin denture base with 0.2% chlorhexidine and 10% castor oil on surface roughness of 3, 4, and 5 years ($p > 0.05$). Castor oil of 10% can be used as a disinfectant for the heat-cured acrylic resin denture base because it does not affect the surface roughness. **Conclusion:** Chlorhexidine 0.2% and castor oil 10% had the same effect on changes in surface roughness on heat polymerized acrylic resin denture base.

Keywords: Denture base, Heat-cured acrylic resin, Chlorhexidine, Surface roughness, Castor oil

ABSTRAK

Pendahuluan: Resin akrilik polimerisasi panas (RAPP) adalah jenis resin akrilik yang paling sering digunakan untuk membuat basis gigi tiruan. Dalam penggunaannya sebagai basis gigi tiruan, RAPP memerlukan bahan desinfektan untuk membersihkannya dari kontaminasi mikroorganisme tetapi tidak memengaruhi sifat-sifat lain dari RAPP tersebut. **Tujuan:** Tujuan penelitian ini untuk menilai pengaruh desinfeksi basis gigi tiruan RAPP dengan klorheksidin dan minyak jarak terhadap kekasaran permukaan. **Materi dan Metode:** Jenis penelitian ini adalah eksperimental laboratoris yang menggunakan 30 sampel basis gigi tiruan resin akrilik polimerisasi panas berbentuk *bar* (50x20x3mm). Spesimen ini dibagi menjadi dua kelompok. Grup I: 15 basis gigi tiruan RAPP masing-masing didesinfeksi dengan klorheksidin 0,2% simulasi 3, 4, dan 5 tahun. Grup II: 15 basis gigi tiruan RAPP masing-masing didesinfeksi dengan minyak jarak 10% simulasi 3, 4, dan 5 tahun. Kekasaran permukaan diuji menggunakan alat *Roughness tester* TR200. Data dianalisis menggunakan statistik univariat dilanjutkan dengan analisis statistik uji t 2 ($\alpha=0.05$). **Hasil:** Penelitian ini menunjukkan bahwa tidak ada pengaruh yang signifikan dalam desinfeksi basis gigi tiruan RAPP dengan klorheksidin 0,2% dan minyak jarak 10% terhadap kekasaran permukaan simulasi 3, 4, dan 5 tahun ($p > 0,05$). **Kesimpulan:** Klorheksidin 0,2% dan minyak jarak 10% memiliki pengaruh yang sama terhadap perubahan kekasaran permukaan basis gigi tiruan resin akrilik polimerisasi panas.

Kata Kunci : Basis gigi tiruan, RAPP, klorheksidin, minyak jarak, kekasaran permukaan.

1. Introduction

Heat-cured acrylic resin is the type of acrylic resin most often used to make denture bases because it has several advantages such as aesthetic quality, good color stability, non-irritating, non-toxic, economical, low residual monomer, minor porosity as well as processing, manufacturing, and easy repair.¹ Acrylic resin has four biological, physical, mechanical, and chemical properties. Surface roughness is one of the physical properties of acrylic resin that can affect the quality of a denture base.² The greater the surface roughness of the denture base, the more staining and calculus buildup

will occur. This will lead to the adhesion of fungal and bacterial biofilms (dental plaque), which can affect the health of the denture-supporting tissues.³ Therefore it is necessary to research an ideal disinfectant agent to inhibit the growth of microorganisms but does not affect or increase the surface roughness of the denture base and can prevent the above from happening.⁴

Chlorhexidine is a disinfectant that is often used today. Chlorhexidine is an antiseptic chemical with broad-spectrum activity that kills bacteria and fungi such as *C. albicans*.⁵ In a study by Jeyapalan et al. (2015), 0.2% chlorhexidine was shown to cause a significant reduction in the amount of plaque when dentures were immersed in it and offered a minor change in surface roughness, among other disinfectants.⁶

Research on disinfectants for dentures is still being carried out because although preparations for denture disinfection have been sold in the market, until now, the ideal denture disinfectant has not been found.⁷ Natural materials have potential as disinfectants that need to be developed. One of the natural ingredients widely studied in the health sector is oil derived from castor seeds (*Ricinus communis*). Castor oil (*Ricinus communis*) is oil derived from castor seeds used in the medical field because of its biocompatibility, bactericide, and fungicide.⁸ The main component of *Ricinus communis* is sodium ricinoleate which can inhibit biofilm formation. This oil is an excellent antimicrobial agent superior to *Staphylococcus aureus*, *Escherichia coli*, and *Candida albicans*.⁹

In Andrade IM et al. (2014) study, 2% castor oil has been effective at a moderate level in removing biofilm on the denture base.¹⁰ Research by Badaro et al. (2017) 10% castor oil effectively removes biofilm because it reduces candidiasis and the formation of microbial colonies on the denture surface.⁹ Another essential consideration is that this oil does not cause changes in the material properties of dentures and acrylic resin, mechanical and physical.¹¹ In the study of Pisani et al. (2012), the surface roughness of three denture component products soaked in 2% castor oil for 15 days (3-year simulation, immersion for 20 minutes per day) showed an insignificant increase in surface roughness, immersion for 183 days (simulation 1.5 years, immersion for 8 hours per day/overnight) in two denture base products there was a decrease in surface roughness while in one other product, there was an increase in surface roughness so that there was a significant difference.¹² In the study of Badaro et al. (2017), 10% castor oil caused a minuscule increase in surface roughness compared to the other solutions, but the values were clinically acceptable.¹¹

Researchers in this study wanted to see whether there was an effect of disinfection of heat-cured acrylic resin denture bases using 0.2% chlorhexidine and 10% castor oil on surface roughness by immersion for 15, 20, and 25 days (simulations 3, 4, and 5 years, with 20 minutes immersion time per day).

2. Material and Methods

The ethics committee has approved this research regarding implementing health research with NO: 901/TGL/KEPK FK USU-RSUP HAM/2019. Samples were divided into six groups, namely: samples immersed in 0.2% chlorhexidine solution for three years (15 days simulation) (A1), samples immersed in 0.2% chlorhexidine solution for four years (20 days simulation) (B1), samples immersed in 0.2% chlorhexidine solution for five years (25 days simulation) (C1), samples immersed in 10% castor oil solution for three years (15 days simulation) (2), samples immersed in 10% castor oil for four years (20 days simulation) (B2), samples were immersed in 10% castor oil solution for five years (25 days simulation) (B3). The research design used was a post-test only with a control group design which gave treatment to one or more groups, and then the results were compared to the control group.

2.1. Sample Preparation

The sample in this study used heat-cured acrylic resin with a size of 50 x 20 x 3 mm (ISO 20795-2013).¹² The number of samples for each group was ten samples. Because there is only one variable to be studied, namely surface roughness with two variations of immersion time, namely simulations of 3, 4, and 5 years, the total number of samples is 30 (The sample preparation treatment process is shown in Figure 1). The study began with the preparation of 10% castor oil solution and 0.2% chlorhexidine, making a metal master model with a size of 50 x 20 x 3 mm $\pm$ 0.5 mm, making the first heat-cured acrylic resin sample by making a mold, after which the resin was filled. Acrylic in the mold with the polymer and monomer mixed in a porcelain pot with a ratio of 2 gr: 1 ml according to the manufacturer's instructions and wait until the dough reaches the dough stage, the mold that has

been smeared with the separator is completely filled with the acrylic resin mixture, plastic cellophane is placed between the top and bottom cuvettes, then closed and gently pressed with a hydraulic press with a pressure of 1000 psi (70 kg/cm²). The cuvette was opened and the excess acrylic was cut off, then the cuvette was closed again, pressing was done with a pressure of 2200 psi (154 kg/cm²) then the bolt was installed.

The curing stage was carried out by inserting a cuvette into a water bath filled with water, the temperature and time were set at 70 oC for 90 minutes, then the temperature was raised to 100 oC for 30 minutes. The cuvettes were removed from the water bath and cooled to room temperature. The sample was removed from the cuvette, then trimmed to remove sharp parts using a Fraser bur. The test rods were then smoothed with waterproof sandpaper with numbers 150, 400, 600, and 1000 under running water until they obtained a size of 50 x 20 x 3 mm. Samples were soaked in distilled water for 48 hours at 37 oC using an incubator before the experiment to reduce residual monomer.

2.2. Surface Roughness Assessment

Measurement of surface roughness in this study was by using a Roughness Tester TR200. The sample is marked with three different lines and measured on each line. After obtaining the surface roughness values of 3 other lines, the average is calculated, and the surface roughness value is obtained. Data analysis used in this study was univariate test analysis to determine the average standard deviation of each group and a t-test to assess the effect of denture disinfection of heat-cured acrylic resin with 0.2% chlorhexidine and 10% castor oil on surface roughness.¹³

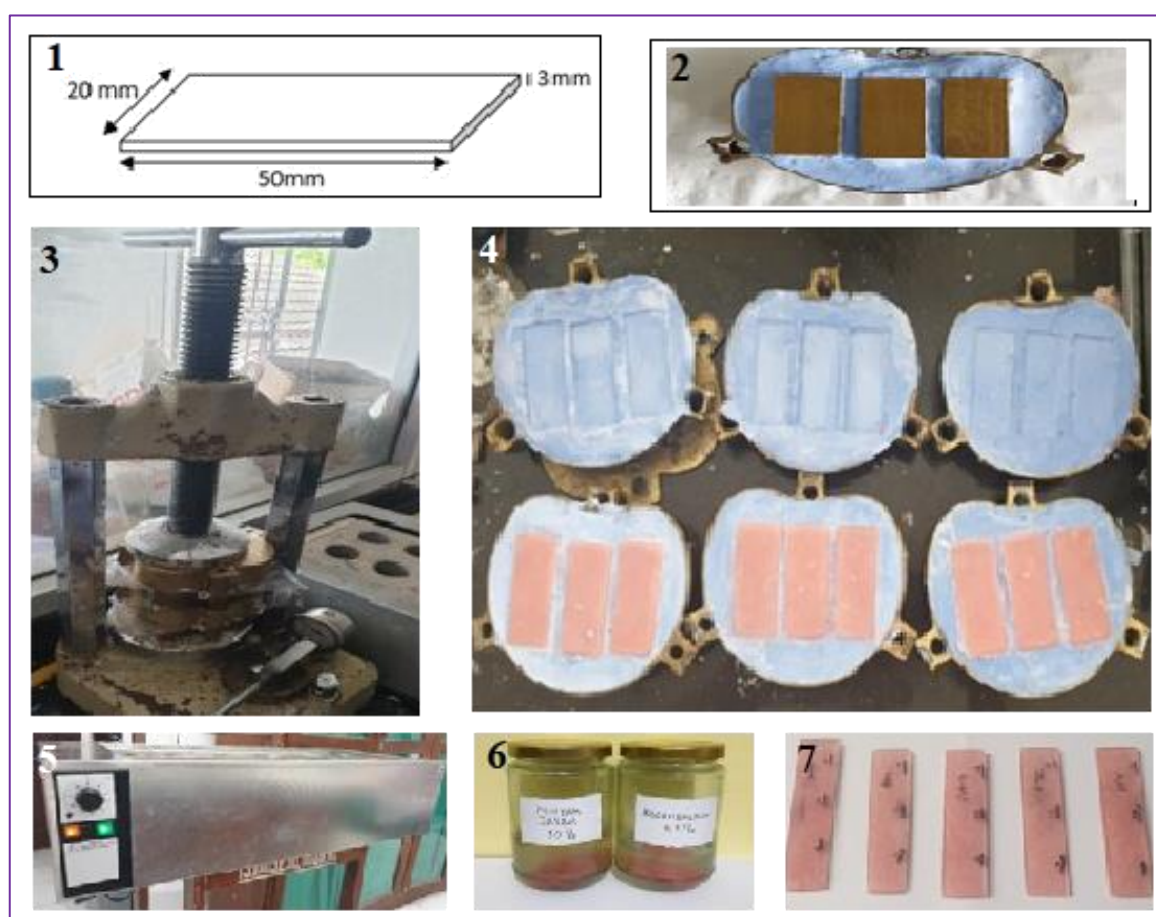


Figure 1. The process of making a sample (mold). (1) Sample shape and size for surface roughness assessment, (2). Mold Making, (3) Hydraulic Press, (4) Acrylic resin after being pressed, (5) Curing Process, (6) Sample Soaking, and (7) Samples marked with three lines

2.3. Statistical Analyses

The normality test of the treatment group used the Shapiro-Wilk, while the data analysis of each comparison group used the T-test.

3. Result and Discussion

The research results obtained were the average value and standard deviation of surface roughness measured using a TR 200 Roughness Tester by calculating the irregularity value on the surface. The surface roughness value of acrylic resin denture base materials is expressed in μm units. Table 1 shows the surface roughness value of a heat-cured acrylic resin denture base after disinfection with 0.2% chlorhexidine and 10% castor oil by immersion simulation for 3, 4, and 5 years.

Table 1. Surface roughness value of heat-cured acrylic resin denture base

No	Surface roughness (μm)					
	A1	B1	A2	B2	A3	B3
1	0,136	0,126	0,111**	0,098	0,077	0,075**
2	0,122*	0,145**	0,105	0,111	0,084	0,074
3	0,140**	0,117*	0,096*	0,097*	0,061*	0,063
4	0,138	0,122	0,109	0,103	0,078	0,073
5	0,125	0,126	0,11	0,112**	0,091**	0,046*
$\bar{x}$	0,132	0,127	0,106	0,104	0,078	0,066
SDV	0,008	0,011	0,006	0,007	0,011	0,012

Description: *Smallest value **Maximum value; (A1) samples soaked in 0.2% chlorhexidine solution for 3 years (simulation 15 days); (B1), samples immersed in 0.2% chlorhexidine solution for 4 years (simulation 20 days); (A2), samples immersed in 0.2% chlorhexidine solution for 5 years (simulation 25 days); (B2), samples immersed in 10% castor oil solution for 3 years (15 days simulation) 5; (A3), samples immersed in 10% castor oil solution for 4 years (20 days simulation) 6; (B3), samples soaked in 10% castor oil solution for 5 years (25 days simulation)

The results showed that the smallest roughness value in the samples disinfected with group A1 was 0.122 μm and the enormous value was 0.140 μm , and the mean value and standard deviation were $0.132 \pm 0.008 \mu\text{m}$. The smallest roughness value in the samples disinfected with group B1 was 0.117 μm , the c value was 0.145 μm , and the mean value and standard deviation were $0.127 \pm 0.011 \mu\text{m}$. The smallest roughness value of the samples disinfected with group A2 was 0.096 μm , the most significant value was 0.111 μm , and the mean value and standard deviation were $0.104 \pm 0.007 \mu\text{m}$. The smallest roughness value in the samples disinfected with group B2 was 0.097 μm , the most considerable value was 0.112 μm , and the mean value and standard deviation were $0.106 \pm 0.006 \mu\text{m}$. The smallest roughness value of the samples disinfected with group A3 was 0.061 μm , the enormous value was 0.091 μm , and the mean value and standard deviation were $0.078 \pm 0.011 \mu\text{m}$. The smallest roughness value of the samples disinfected with group B3 was 0.046 μm , the immense value was 0.075 μm , and the mean value and standard deviation were $0.066 \pm 0.012 \mu\text{m}$ (Table 1).

Table 2. Surface roughness of heat-cured acrylic resin dentures after disinfection

Groups	Surface roughness (μm)		*p-Value
	N	$\bar{x} \pm \text{SD}$	
A1	5	0,132 $\pm$ 0,008	0,427
B1	5	0,127 $\pm$ 0,011	
A2	5	0,104 $\pm$ 0,007	0,645
B2	5	0,106 $\pm$ 0,006	
A3	5	0,066 $\pm$ 0,012	0,144
B3	5	0,078 $\pm$ 0,011	

* T-test ; (A1) samples soaked in 0.2% chlorhexidine solution for 3 years (simulation 15 days); (B1), samples immersed in 0.2% chlorhexidine solution for 4 years (simulation 20 days); (A2), samples immersed in 0.2% chlorhexidine solution for 5 years (simulation 25 days); (B2), samples immersed in 10% castor oil solution for 3 years (15 days simulation) 5; (A3), samples immersed in 10% castor oil solution for 4 years (20 days simulation) 6; (B3), samples soaked in 10% castor oil solution for 5 years (25 days simulation)

Before testing, a normality test was performed on the surface roughness value to determine the normal distribution of the data. Using the Shapiro-Wilk test, the normality test was carried out

on surface roughness values. All p values were obtained > 0.05 , meaning that the data were typically distributed to determine the effect of denture disinfection of heat polymerized acrylic resin with 0.2% chlorhexidine and 10% castor oil on the surface roughness value was analyzed statistically by t-test. Table 2. Surface roughness of heat-cured acrylic resin denture after disinfection with 0.2% chlorhexidine and 10% castor oil on surface roughness by immersion simulation for 3, 4, and 5 years. The statistical test results obtained the significance level of groups A1 and B1, namely p value = 0.427 ($p > 0.05$), groups A2 and B2, namely p value = 0.645, groups A3 and B3, namely p value = 0.144, indicating that there was no effect significantly on the disinfection of Heat-cured acrylic resin denture bases with 0.2% chlorhexidine and 10% castor oil on surface roughness values.

The results of this study obtained varying surface roughness values for each sample in one group. The difference in roughness values may be due to differences in the mechanism of action of disinfection between 0.2% chlorhexidine and 10% castor oil, the ingredients of each disinfectant, and the soaking time. The varying surface roughness values may also be because the surface of the Heat-cured acrylic resin denture base was polished manually using sandpaper which did not obtain the same pressure. As a result, the smoothness level on the entire surface was also not the same.¹⁴

The above results also show that the average surface roughness values in the two disinfection groups within 3, 4, and 5 years do not exceed the standard dental material roughness value of 0.2 μm . The average value in each group shows that the longer the immersion duration, the mean surface roughness value decreases. This happened because the acrylic resin base soaking process had been carried out for 48 hours in distilled water before the immersion process. Filling the space of the specimen with water molecules so that the water absorption has been saturated, resulting in a lower amount of residual monomer as the immersion duration increases. As a result, the change in surface roughness value becomes smaller the longer it is soaked.¹⁵

This study's results follow previous research from Salles et al. (2015), which evaluated 2% castor oil and showed insignificant changes in surface roughness and hardness and the color of the acrylic resin base. et al. (2012), the surface roughness of three denture component products immersed in 2% castor oil for 15 days (3 years of simulation, immersion for 20 minutes per day) changed the surface roughness value but showed no statistically significant difference. The content of castor oil, namely ricinoleic acid, a weak acid, affects it. Heat-cured acrylic resin has ethylene glycol dimethacrylate as a cross-linking which has sufficient resistance to weak acids so that the castor oil content, which is also absorbed during the diffusion process, does not affect the surface roughness of the heat-cured acrylic resin base or the surface roughness value becomes stable.¹⁶

The results of this study also follow previous studies from Jepayalan et al. (2015) that 0.2% chlorhexidine showed the most negligible effect on surface roughness and did not cross the threshold among other disinfectants. 4 The factor causing surface roughness is due to chlorine in Chlorhexidine solution can damage the interstitial matrix of acrylic resin causing the release of residual monomers and plasticizers causing irregularities on the surface of the object. Changes in the surface roughness of the two disinfectants also occurred because the two groups of samples had been soaked in water for 48 hours which reduced the amount of residual monomer, making the acrylic resin samples saturated, and the water absorption process during immersion was small so that there was no effect on surface roughness.¹⁷

The decrease in the surface roughness of the acrylic resin after immersion in the disinfection solution was caused by the weak acid content in the castor oil solution, which did not cause degradation of the polymer bonds, so the acrylic resin polymer bonds were stable.¹⁸ The oil content in the castor oil disinfection solution makes the surface of the denture base. The longer the immersion time, the smoother the surface. This is due to the synthesis process of acyloxy castor polyol ester on the denture base surface of Heat-cured acrylic resin so that the base surface becomes smoother.¹⁹ Besides that, according to Lubis A's research, differences in heat-cured acrylic resin samples used for each group can also be a cause. This depends on how the material is manipulated, the composition of the material, and the porosity which is not visible during the manufacturing process, the curing process, and the sample polishing process.²⁰

Immersion time also has an essential role in affecting the surface roughness of the Heat-cured acrylic resin denture base. The longer the immersion of the heat-cured acrylic resin denture base, the more time it takes for the solution to penetrate the material, and the more the active substance that has disinfection is also absorbed and undergoes reaction or chemical damage to the elements of the heat-cured acrylic resin, namely ethylene.²¹ Glycol methacrylate as a cross-linking agent in acrylic resin which affects the surface roughness of the heat-cured acrylic resin base, but before the soaking process,

the disinfection material is also carried out the process of saturating the residual monomer in distilled water which causes a lower residual monomer so that the longer the soaking time little solution penetrates the material causing a decrease in surface roughness.¹⁷

The weakness in this study that could affect the surface roughness value of the heat-polymerized acrylic resin denture base was the manual polishing process with sandpaper causing a difference in pressure on each sample surface during polishing.²² The differences in the Heat-cured acrylic resin samples used for each group were also a weakness in this study. This is because the researchers did not measure the surface roughness values in each group before immersion. These things certainly greatly influence the research results obtained.²³

4. Conclusion

The results showed no significant difference between 0.2% chlorhexidine and 10% castor oil on the surface roughness of the Heat-cured acrylic resin denture base. Still, the use of chlorhexidine disinfection in the long term could cause taste disturbances and staining of the denture, so Castor oil can be used as an alternative for denture base disinfection because it does not affect the surface roughness of the heat-polymerized acrylic resin denture base.

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Authors Contribution

Contribution	Gaol EL	Ritonga PWU
Concepts or ideas	√	√
Design	√	√
Definition of intellectual content	√	
Literature search		√
Experimental studies	√	
Data acquisition		√
Data analysis	√	√
Statistical analysis	√	√
Manuscript preparation	√	√
Manuscript editing	√	√
Manuscript review	√	√



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