

Effect of different polishing methods applied to denture base materials on microbial adhesion and surface roughness

Sadi Yazar¹ , Yalçın Değer² , Samet Tekin³ 

¹ Private Practice, San Jose, CA, USA

² Dicle University, Faculty of Dentistry, Department of Prosthodontics, Diyarbakır, Türkiye

³ Fırat University, Faculty of Dentistry, Department Prosthodontics, Elazığ, Türkiye

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Correspondence:

Dr. Samet TEKİN

Fırat University, Faculty of Dentistry,
Department Prosthodontics, Elazığ,
Türkiye

E-mail: s.tekin@firat.edu.tr



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Abstract

Aim: The aim of our study was to investigate the effect of various polishing processes applied to different types of PMMA (polymethyl methacrylate) denture base materials on the surface roughness and microbial adhesion of the base material.

Methods: Sixty specimens were prepared from heat-polymerized conventional PMMA (G), injectable PMMA (E), and pre-polymerized CAD-CAM PMMA (C) denture base materials. All the sample surfaces were sanded with silicon carbide abrasives of 800, 1000, 1200, and 2500 grit. The specimens of each denture base material were divided into three subgroups (n=20), in which different polishing methods were applied. The first group was mechanically polished (M), and the other two groups were chemically polished with light-polymerized glaze liquids [Palaseal (Ps), Optiglaze Color (Og)]. A profilometer was used to evaluate the surface roughness. Colony counting was performed to assess bacterial colonization after one day. The data obtained from all these measurements were evaluated using Analysis of Variance and Bonferroni Corrected test was used for multiple comparisons of means ($p = 0.05$). The interaction between surface roughness and bacterial colonization was examined using the Pearson's correlation test. Regression analysis was performed to determine the relationships between them.

Results: When PMMA base materials were compared, the lowest average surface roughness (Ra) and bacterial colonization values were obtained in Group C. When the polishing methods were compared, the lowest average surface roughness values were obtained for Group M. As a result of the bacterial colonization measurement, lower colonization values were obtained with standardized mechanical polishing compared to the other groups.

Conclusion: There was no difference between the different PMMA base materials in terms of surface roughness; however, there were statistically significant differences in bacterial colonization. Our study showed that mechanical polishing yielded better results than light-activated glazing agents.

Keywords: CAD-CAM, digital, PMMA, polishing, surface roughness

Introduction

The surface roughness of the materials used in prosthesis production is clinically important because it affects plaque formation and coloration of the material [1]. Surface roughness is an important feature that directly affects the health of oral tissues in contact with prostheses. Studies have shown that the adhesion of microorganisms to rough surfaces is higher than that to smooth surfaces, and rough surfaces create a protected environment, making it difficult to remove microorganisms using oral hygiene methods [2]. Intraoral lesions are frequently observed in people who use removable dentures due to denture stomatitis. *Staphylococcus aureus* (*S. aureus*) is a bacterial species that has high adhesion to the oral mucosa and can cause oral mucosal lesions such as denture stomatitis [3].

Abrasion caused by chewing and mechanical cleaning, poor oral hygiene, and decreased saliva production can lead to high plaque accumulation and may cause stomatitis and oral candidiasis [4]. Therefore, mechanical polishing or glazing is usually performed to reduce the attachment of microorganisms to the complete denture surface [5].

Mechanical polishing of the inner surface of the prosthesis was not performed. However, the smoothness of prosthesis surfaces in contact with the mucosa increases patient satisfaction by facilitating the removal of microorganisms and residues [6]. However, owing to the low thermal conductivity of acrylic, overheating can occur during polishing. It has been stated that excessive polishing should not be performed because this may cause deterioration of the appearance of the prosthesis surface, and the aesthetic quality of the acrylic resin may deteriorate [7]. Today, chemical polishing can be performed without heat application by applying new polishing agents developed for this purpose to the surface and activating these agents with light. Manufacturers state that these polishing materials, which they call glazing agents, create a smooth acrylic resin surface, reduce food residue accumulation and plaque adhesion, and improve oral hygiene [8]. Chemical polishing techniques have several advantages over conventional mechanical polishing techniques. Chemical polishing can easily reach areas and recessed surfaces that cannot be achieved by mechanical polishing and allows polishing of the inner surface of the prosthesis. Chemical polishing is easier to apply and requires less time [9].

The aim of this study was to investigate the polishability of prepolymerized CAD-CAM PMMA, injectable PMMA, and heat-polymerized conventional PMMA denture base materials, and to evaluate the effect of conventional mechanical polishing and glazing with different agents on the surface roughness and bacterial colonization of PMMA base materials.

The null hypotheses of our study were:

1. There is no difference in surface roughness between the different types of PMMA base

materials because of the different surface finishing and polishing processes applied to the materials.

2. There is no difference in bacterial adhesion between the different materials we used as a result of different surface finishing and polishing processes applied.
3. The various polishing processes applied to the different types of PMMA denture base materials did not affect the surface roughness of the base material or microorganism colonization.

Materials and Methods

Sixty specimens were prepared from heat-polymerized conventional PMMA (G), injectable PMMA (E), and pre-polymerized CAD-CAM PMMA (C) denture base materials.

Preparation of test samples

In our study, wax samples of equal size (10x10x3 mm) were used as molds to form the groups, and the materials listed in Table 1 were used.

Table 1. Materials used in our study.

	Product Name	Material Type	Company
Acrylic Resin Base Material (n=60)	Weropress (C) (n=20)	Heat Polymerized Acrylic Resin	Merz Dental GmbH, Lütjenburg, Germany
	SR Ivocap (I) (n=20)	High Impact Injectable Acrylic Resin	Ivoclar Vivadent AG, Schaan, Liechtenstein
	On-dent CAD-CAM Milling Disc (M) (n=20)	Prefabricated Polymerized CAD-CAM Acrylic Resin	On-Dent, İzmir, Turkey
Polishing Material (n=60)	Palaseal (Ps) (n=20)	Light-Polymerized Glaze Liquid	Heraeus Kulzer GMBH, Hanau, Germany
	Optiglaze color (Og) (n=20)	Light-Polymerized Glaze Liquid	GC Corporation, Tokyo, Japan
	Mechanical Polishing (M) (n=20)	Felt discs Water-based polycrystalline diamond suspension	Struers, Germany Diapat, Metkon, Turkey

Preparation of heat-polymerized conventional PMMA samples

The wax specimens were covered with a high-viscosity polyvinylsiloxane impression material and then traditionally muffled with type 3 hard gypsum. After the gypsum hardened, clean boiling water was poured over the wax samples to remove the wax. All silicone surfaces were then isolated by applying a lacquer with a brush and left for 3 min. The powder and liquid parts were mixed in a clean glass container for 15 s at a ratio of 21 g powder/10 ml liquid, using Weropress's special scales. The mixing container was covered and kept at room temperature for approximately 9 min. When the prepared acrylic paste reached the fiber stage, it was placed in the sample cavity. The cavities were closed in accordance with the manufacturer's recommendations after proof closing two times in a hydraulic press, cleaning the overflowing parts, and keeping in a thermostat water tank first in 72 °C water for 90 min and then in boiling water for 30 min. After polymerization in hot water, the muffles were removed from the water, allowed to cool to room temperature for 30 min, and opened.

Preparation of injectable PMMA samples

Wax samples were placed in a flask in accordance with the manufacturer's recommendations, and a 5 mm diameter injection syringe was created. The wax was removed, and a lacquer was applied to the plaster surfaces. The acrylic paste was obtained by mixing the powder and liquid parts (20 g powder/30 ml liquid) in their own packages in a vibrator for 5 min at room temperature. The pressure apparatus was placed on the flask, and acrylic was injected by applying a pressure of 6 bar.

The flask was placed in boiling water in a polymerization bath. The surface of the water was covered with plastic balls to prevent heat loss. Polymerization was completed within 35 min by applying a constant pressure of 6 bar throughout the process and ensuring that the water was boiled.

Preparation of PMMA samples from CAD-CAM discs

A wax sample was scanned in a CAD (Exocad DentalCAD, Exocad GmbH, Darmstadt, Germany) system, and the resulting images were digitally transferred. To obtain standard samples from the CAD-CAM PMMA (On-Dent, Izmir, Turkey) disk, the design stereolithography (STL) file was transferred to the CAM (VHF K5, vhf camfacture AG, Ammerbuch, Germany) device, and the samples were obtained by milling.

Three subgroups of 60 samples with different surface treatments were created for each material used in our study (n=20).

Preparation of sample surfaces

For the standard polishing of the sample surfaces, the samples were embedded in C-type laboratory silicone in groups of three. Surface standardization was achieved by sanding all sample surfaces with 2500 grit silicon carbide abrasives for 10 s in a water bath in an automatic abrasive-polish device (LaboPol-5, Struer, Germany) at a fixed speed of 300 rpm.

Among the samples whose surfaces were standardized by sanding in the abrasive-polish device, the samples in the mechanical polishing group were polished with felt discs and a water-based polycrystalline diamond suspension by a single applicator on the same device for 10 seconds.

In the chemical polishing groups, a light-activated glaze liquid was applied to the sample surfaces in a thin layer in one direction, separately for each sample, with its own soft brush. In accordance with the manufacturer's recommendations, the samples were stored in a photopolymerization device (Solidilite V, Shofu Dental GmbH, Ratingen, Germany) for 90 s.

Surface roughness measurement

A profilometer (SJ-301; Mitutoyo Corp, Kawasaki, Japan) was used for the surface roughness measurements (0.01 µm resolution for 5 s with a 0.4-gram load). The samples were compressed by placing them in a special fixture such that they could be held in a stable position. The roughness measurements were obtained from three separate areas on the sample surfaces. The measurements were averaged, and the average surface roughness (Ra) of each sample recorded. The instrument was calibrated after measuring each sample group.

Scanning electron microscopy (SEM) examination

Nine samples from each subgroup were analyzed. SEM was used to observe the homogeneity of the materials and determine the effects of mechanical polishing and glazing on the surface morphology. Before imaging, these surfaces were coated with gold-palladium using the "sputter coating" technique [Precision Etching and Coating System (PECS); (Gatan, Inc., Pleasanton, USA)].

Measurement of the size of bacterial colonization

In our study, the *Staphylococcus aureus* ATCC 25923 standard strain was used to determine the amount of contaminated microorganisms attached to the surface of the base materials. Samples for bacterial colonization and attachment were disinfected using 70% alcohol and washed with sterile distilled water in an ultrasonic washer for 5 min. *S. aureus* bacteria were removed from -80°C in a deep freezer, inoculated on 5% sheep blood agar medium (RTA, Turkey), and incubated in a

microaerobic environment at 37°C for 24 h. A bacterial suspension was prepared from the microorganisms using 5 ml of saline. The turbidity of the suspension was adjusted according to 0.5 McFarland standards using a densitometer. Thus, 150×10^6 colony-forming units (CFU) of the microorganisms were ensured in 1 ml of the suspension. Each sample was stored separately in tubes for 15 min to ensure contamination. At the end of this time, the samples were removed from the tubes with the help of a sterile clamp, and loosely attached microorganisms were removed by immersing each sample 20 times in 10 ml of sterile phosphate buffer solution (PBS). After washing, the samples were transferred to test tubes containing 2 ml of sterile PBS and shaken vigorously on a mixer for 5 min to remove microorganisms attached to the surfaces.

Then, 0.01 ml of PBS was taken from each tube separately using sterile micropipettes and inoculated onto plates containing sheep blood medium for *S. aureus* by rotating with sterile cotton swabs to distribute it evenly in each region. The plates were then incubated at 37°C for 24 h. At the end of incubation, colony counting was performed, and the total number of bacteria was calculated as "CFU." (Fig. 1).



Figure 1. *S. aureus* colonies grown on sheep blood agar medium.

Statistical analysis

The data were analyzed using IBM SPSS 25.0 software (IBM SPSS Inc., Armonk, NY, USA).

The data obtained to determine the average roughness profile of the samples and the data obtained from the bacterial colonization measurements were evaluated using Analysis of Variance because they were normally distributed, and the Bonferroni test was used for multiple comparisons of means ($p=0.05$). Bacterial colonization values for each group one day later were compared using the Student-Newman-Keuls test.

To evaluate the interaction between surface roughness and bacterial colonization, the relationship between these properties was examined using the Pearson's rank correlation test. Regression Analysis was performed to determine the relationship between them.

Results

The surface roughness (Ra) values obtained as a result of the surface roughness test were investigated using the Kolmogorov-Smirnov test for conformity to the normal distribution, and all data were found to conform to the normal distribution. The average surface roughness values obtained in micrometers are listed in Table 2.

Table 2. Surface roughness values of the groups.

Groups	Surface preparation	Surface roughness (Ra)	P
C	M	0.06	$p<0.05$
	Ps	0.44*	
	Og	0.42*	
I	M	0.05	
	Ps	0.32*	
	Og	0.32*	
M	M	0.04	
	Ps	0.28*	
	Og	0.31*	

*: It represents a significant difference according to mechanical polishing groups.

When the surface roughness values of the polishing methods applied to the heat-polymerized PMMA samples were compared, no statistically significant difference was observed between the Ps and Og groups ($p > 0.05$). The M group showed significantly lower values than the Ps and Og groups ($p < 0.05$).

The surface roughness values of different PMMA base materials subjected to mechanical, Palaseal-glaze, and Optiglaze polishing did not differ statistically.

The values obtained as a result of the bacterial colonization measurement after one day using the colony counting method were investigated for compatibility with the normal distribution using the Kolmogorov-Smirnov test, and all data were found to be in accordance with the normal distribution. The bacterial colonization values after one day are shown in Table 3.

The CFU values were statistically different among the polishing methods for all PMMA groups. According to the polishing method, the order of CFU values was $Og>Ps>M$.

The CFU values for all polishing methods were also statistically different. The order of CFU values was $C>I>M$.

Table 3. Bacterial colonization values of the groups after one day.

Groups	Surface preparation	CFU	P
C	M	43.8	<i>p</i> <0.05
	Ps	55.6	
	Og	73.25	
I	M	37.05	
	Ps	44.45	
	Og	51.2	
M	M	17.4	
	Ps	23.75	
	Og	30.8	

Results of SEM images

To examine the differences in the surface morphology of the PMMA base materials in more detail, SEM photographs were evaluated at x500 magnification. Differences were observed in the surface morphologies of the PMMA samples.

The injectable PMMA samples showed irregular indentations and craters on their surfaces, whereas the heat-polymerized conventional PMMA samples exhibited a rougher surface structure.

In the milled PMMA samples, the surfaces were found to be less rough, more uniform, and homogeneously distributed than those of the other base materials.

When the SEM images of the chemically polished samples were examined, it was found that a relatively rough surface filled with small irregularly distributed dots and air bubbles was formed in the glaze layer. For the mechanically polished samples, topographical images with peaks and pits extending parallel to each other were observed.

Discussion

The PMMA base blocks used in the CAD/CAM systems were produced under high pressure and heat. Therefore, the shrinkage problem observed in the conventional method for milled prostheses was prevented. In addition, because the blocks have high condensation, the residual monomer and porosity are low [10]. Studies have shown that rough acrylic surfaces are significantly more prone to the accumulation of microorganisms and plaque formation than smooth surfaces and that the surface roughness of the resin depends on the particle size of the polisher [2,11]. Surface roughness is an important property that directly affects the health of oral tissues in contact with the prosthesis. An increase of 0.3 µm in surface roughness can be recognized with the tip of the patient's tongue [12]. However, it has been reported that

a dramatic increase in colonization can be expected from a surface roughness value of 0.2 µm. In vivo studies have shown that surface roughness plays a more important role in plaque formation than free surface energy [1]. Zissis et al. reported that the surface roughness of four prosthesis base resins was above 0.2 µm after polymerization without any surface treatment [13]. Therefore, in our study, in addition to the sanding process, the sample surfaces in the mechanical polishing groups were polished with a water-based polycrystalline diamond suspension using a felt for 10 seconds in an abrasive-polishing device.

In our study, the average Ra values of the samples prepared from mechanically polished pre-polymerized CAD-CAM PMMA blocks were 0.04 µm. Steinmassl et al. examined the surface properties of prepolymerized CAD-CAM PMMA without any surface treatment and found a Ra value of 0.28 µm [14]. The differences in the Ra values in the aforementioned studies can be attributed to the different polishing techniques and tools used. In our study, although we found the lowest average surface roughness values in the CAD-CAM PMMA samples, our results reveal that CAD-CAM PMMA does not show a statistically significant difference in terms of surface roughness when compared to conventional heat-polymerized PMMA. Thus, the first null hypothesis, that there is no difference in surface roughness between heat-polymerized conventional PMMA and prepolymerized PMMA used to produce CAD-CAM-assisted removable prostheses, was accepted. In addition, in this study, the surface roughness values of all mechanically polished PMMA samples were below the reported threshold value (0.2 µm).

Surface roughness leads to plaque accumulation on the prosthesis and discoloration in certain parts of the prosthesis. Our SEM analysis shows that there is more roughness on the surface of the heat-polymerized conventional PMMA samples compared to the prepolymerized CAD-CAM PMMA samples. These roughness factors create a protected environment [15]. The presence of roughness on the surface of heat-polymerized conventional PMMA revealed by SEM examination explains the higher surface roughness values of these acrylic samples.

Arslan et al. found that the hydrophobicity of CAD-CAM PMMA-based polymers was higher than that of conventional heat-polymerized PMMA, whereas prepolymerized CAD-CAM PMMA-based polymers had Ra values similar to those of conventional PMMA [16]. Although surface roughness is an important parameter affecting microorganism colonization, we did not find a statistically significant difference in surface roughness between CAD-CAM PMMA and heat-polymerized conventional PMMA in our study.

Our results showed that the surface roughness values of the CAD-CAM PMMA samples, which were subjected to both mechanical and chemical polishing (coating the surface with light-curing glazing agents), were lower than those of the heat-polymerized injectable PMMA. This may be due to the inherent properties of the CAM polymer materials and the

manufacturing process. This is because CAD-CAM polymer materials are polymerized at high temperatures and pressures [9].

The initial microbial adhesion to the prosthetic base material depends on the physical properties of the material surface, such as the roughness, surface free energy, hydrophobicity, and roughness [2, 17]. All these variables are affected by the type of material used in the preparation of the prosthesis, polymerization method, addition of fibers to the material, or any surface modification (such as surface coating) [18].

S. aureus, whose surface adhesion was evaluated in our study, is a bacterial species present on denture plates in patients with denture stomatitis. *S. aureus* was found on the oral mucosa in 84% of the patients with denture stomatitis and on the denture surface in 36% of the patients. However, the incidence of *Candida albicans* in patients with denture stomatitis is 86% in the oral mucosa and 26% in the denture surface [3].

In the studies, *Candida albicans* attachment has been examined more frequently, and it is seen that the studies using *S. aureus* are limited. Baena-Monroy et al. found that *S. aureus* rates were similar to those of *Candida albicans* [3]. Therefore, in our study, the adhesion of *S. aureus* on the surface was evaluated in order to be up-to-date and to shed light on this issue.

Verran and Maryan polished the surface and roughened the surface of ready-to-use sheet PMMA resin with a Ra value of 0.2 μm with 600 grit sandpaper and obtained a Ra value of 1.26 μm . [19] A significantly higher number of *Candida albicans* was observed on the roughened surfaces than on the unroughened surfaces.

While there were no statistically significant differences between the attachment of *S. oralis* and *A. viscosus* to sample surfaces with different surface finishes, *Candida albicans* attachment was significantly higher on sandblasted and untreated surfaces after exiting the muffle than on polished surfaces [20].

Bacterial attachment was higher on rough surfaces than smooth surfaces, and bacterial attachment was higher on autopolymerized acrylic resin samples than on heat-polymerized acrylic. They stated that the surface roughness of autopolymerized acrylic resin samples was higher than that of heat-polymerized acrylic resin under all conditions could be explained by the harder surface of heat-polymerized acrylic resin [11].

Prepolymerized CAD-CAM PMMA denture base acrylics are more hydrophobic than conventional heat-polymerized PMMA base acrylics because they contain less residual monomers. In addition, owing to the lack of roughness in prepolymerized CAD-CAM PMMA polymers, microorganisms such as *C. Albicans* are less likely to adhere to the prosthesis [21].

According to our findings, *S. aureus* colonization in specimens obtained from prepolymerized CAD-CAM PMMA was lower than that in specimens obtained from conventional heat-polymerized PMMA. Therefore, the second null hypothesis, that the amount of *S. aureus* adhering to prepolymerized CAD-CAM PMMA-based polymers is not different from that of heat-polymerized conventional PMMA, was rejected.

We believe that roughness or surface hydrophobicity may have a significant effect on *S. aureus* colonization, since there was no significant difference in surface roughness between the test samples obtained from the different types of mechanically polished PMMA.

Since the surface roughness results found in our study were less than 0.2 μm , it is not expected to reduce microbial colonization further [22]. Therefore, similar surface roughness results would provide similar microbial adhesion conditions for all the three PMMA base acrylics. This indicates that different factors are also involved in *S. aureus* colonization. In addition, according to the findings obtained in our study, *S. aureus* adhered more to acrylic surfaces with a higher surface roughness. This result, in accordance with previous studies, supports the assertion that microorganism adhesion increases with surface roughness because as the roughness increases, the surface area required for microorganism adhesion is provided [5]. The main difference in our study is that the effect of surface roughness on bacterial attachment was not statistically significant because the surface roughness values we obtained by applying standardized mechanical polishing were below 0.2 μm . Therefore, the Ra values we found did not sufficiently affect bacterial adhesion.

Injectable acrylics are available in pre-mixed cartridges, whereas in the traditional technique, the powder and liquid are mixed by hand, which can cause air bubbles to remain in the material, resulting in increased surface roughness [23]. The adhesion of *C. albicans* to injectable acrylic materials was found to be lower than that of conventional acrylic resins [24], which is consistent with our research results. However, Young et al. reported that the adhesion of *C. albicans* to injectable acrylic materials was not significantly different from that of conventional and autopolymerized acrylic resins [25]. The difference between the results of Young et al. and our study may be due to differences in the type of microorganism used or the procedure in the microbial colonization experiments. There is no standard method for colonization experiments and colony counting methods.

A comparison of the surfaces of two acrylic resin materials (heat-polymerized conventional PMMA and injectable PMMA) by SEM analysis shows that the surface structure of conventional heat-polymerized PMMA is rougher. These surface structural differences are consistent with the results reported by Young et al. These surface structural differences may be another reason for the difference between the results of the study by Young et al. and our study. In addition, roughness, such as surface roughness, increases plaque formation on the prosthesis surface and coloration of certain parts of the prosthesis. Because of the roughness of the surface, fungi and bacteria are better protected from the shear force generated by mechanical cleaning [15].

Glazing agents are recommended to optimize restorations, especially to increase surface smoothness by filling microcracks and microdefects formed after finishing and polishing processes with capillary action.

However, glazing agents can cause problems of poor surface quality over time owing to low abrasion resistance, poor bonding to the underlying material, and uneven spreading owing to high viscosity [26]. Bacterial colonization was reported to be significantly lower on glazed surfaces than on unglazed surfaces [27]. Oliveira et al. reported that the surface roughness was lower in mechanical polishing groups than in chemical polishing groups. In addition, prolonged use of glazing agents may cause surface cracks and, consequently, a further increase in colonization [28].

According to our research findings, the conventional mechanical polishing process performed in the laboratory is an effective and sufficient method to reduce the surface roughness. However, chemical polishing is also a preferable method considering its advantages, such as reaching the recessed areas on the prosthesis and the inner surface of the prosthesis, which cannot be achieved by mechanical polishing, polishing these areas, short processing time, and requiring less equipment.

Studies have shown that it has a positive effect on surface roughness by filling microcracks and microdefects that occur after finishing or polishing of surface sealants or glazing materials [26].

In our study, we applied Palaseal (light-curing glazing material) and Optiglaze Color glazing agents to the acrylic resin surface for chemical polishing to reduce the adhesion of *S. aureus* to the acrylic surface. We observed that *S. aureus* adhesion was lower in the samples that were mechanically polished compared to the samples with Palaseal and Optiglaze glazing agents. *S. aureus* adhesion to the polished surfaces may be due to the differences in surface properties, that is, roughness, as we found that the average surface roughness values of the samples in all groups where we applied mechanical polishing were lower than those of the samples where we applied glazing agents for chemical polishing. Based on these results, the third null hypothesis was rejected.

In our study, we did not find a statistically significant difference between the mean surface roughness values of the samples treated with different glazing agents, but in our findings, we found lower bacterial colonization on the surfaces of the samples coated with Palaseal compared to Optiglaze Color. Therefore, we believe that the differences in the degree of adhesion of *S. aureus* to glazed surfaces are due to differences in surface properties, contact angle (hydrophilicity) differences caused by different agents, and chemical structures of the glazing agents used.

Conclusion

The conclusions reached within the limitations of our study are as follows:

1. If a standard mechanical polishing technique is used to polish heat-polymerized conventional PMMA denture base acrylics, the results can be as good as those

of prepolymerized CAD-CAM PMMA denture base acrylics in terms of surface roughness.

3. Mechanical polishing is a more effective method to reduce surface roughness than chemical polishing (coating the surface with light-polymerized glazing agents).

4. According to the results of our study, *S. aureus* was found to adhere more to the test samples obtained from heat-polymerized conventional PMMA.

5. It can be said that the adhesion of *S. aureus* to prepolymerized CAD-CAM PMMA base materials is less than that of heat-polymerized conventional PMMA base materials.

6. Removable prostheses produced using CAD-CAM technology can be considered an important treatment alternative, especially in patients with severely suppressed immune systems.

Disclosures

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