Evaluation of a Glaze Polishing Technique for Pigmented Denture Acrylic Resin Submitted to Thermocycling and Disinfection

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Abstract

Aims: Compare the mechanical and physical properties of two polishing techniques for acrylic resins under the influence of disinfection. **Materials and Methods:** Two hundred and eight circular samples (10 mm diameter × 3 mm height) were manufactured, with 160 for the color stability, hardness, surface roughness, and wettability ($n = 10$) analyses, and 48 for the scanning electron microscopy and atomic force microscopy evaluation ($n = 1$). Two brands of prosthesis acrylic resin, Onda Cryl and Lucitone, were used to manufacture the samples. Half of the samples were intrinsically pigmented with a purple acrylic pigment (Policor) at 7% of the total weight in powder; half of those received the mechanical polish with sand paper under constant water irrigation in a universal polishing machine at 300 rpm (control), and half received a uniform coat of a photopolymerized glaze (Megaseal) to be tested. The samples were kept immersed in distilled water for 24 h before the initial measurements (T0), afterward, they were divided into two disinfection procedures; half were disinfected through microwave energy and half through cleaning tablets (Efferdent) for 60 days (T1). **Results:** The glaze polished groups presented inferior chromatic stability and the pigments prevented discoloration for the glaze polish. The disinfectant solutions promoted a superficial degradation of the acrylic resin for both polishing techniques. Lucitone presented higher hardness values than Onda Cryl ($P < 0.001$) and the glaze technique had higher hardness values than the mechanic polish. **Conclusion:** The photopolymerized glaze improved some characteristics of the acrylic resin, such as the surface hardness and roughness suggesting it is an adequate polish for acrylic resins.

Keywords: Acrylic resins, dental polishing, disinfection, pigmentation

Introduction

Acrylic resin is the most commonly used material to manufacture conventional removable prostheses; it is a low-cost material, has good adaptability to oral tissue, it is easy to manipulate, and possesses satisfactory esthetic characteristics.[1-3]

The acrylic resin must mimic the soft tissue features to provide an excellent esthetic outcome,[4] and there are two techniques to do so: An extrinsic characterization in which the pigments are added after the polymerization process; and an intrinsic characterization in which the pigments are incorporated into the acrylic before the polymerization. The intrinsic technique provides good results since pigmentation is internal. The pigments age with the prosthetic material and are not influenced by damage on the prosthesis surface.[2]

Some physical properties are directly linked to material longevity, such as microhardness, surface roughness, and color stability. These properties can be influenced through time due to constant temperature changes, contact to wet oral tissues, the disinfection process used, and contact to different solutions.[1,5-13]

Different polishing techniques have been used in an attempt to improve these characteristics; the polish can be mechanical, performed with different polishing pastes and soft brushes, or

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chemical, in which the acrylic prosthesis is immersed in the heated monomer.[14,15] Now, a new method has been reported in published literature; a surface coating with a photopolymerized glaze.[9,10]

Dental materials suffer constant degradation during the rehabilitation process and clinical use, which can lead to a modification in their mechanical and physical properties.[16] Constant contact with humidity and alternating temperatures in the oral cavity are examples of stress on the material. In addition, contact to pigmented food, and the disinfection applied, can increase the amount of stress and induce further degradation characteristics.[2,3,17]

The disinfection of complete prostheses can be performed with chlorhexidine gluconate, sodium hypochlorite, alkali, and peroxide solutions, as well as with microwave energy.[2,3,17-19] Chlorhexidine gluconate and effervescent tablets are effective in the reduction of microorganisms, but can induce a surface degradation.[18] Microwave disinfection was proven effective against candida species, however, it was associated to color and hardness changes in acrylic resin.[2,3,17,19] Yet, microwave energy and effervescent tablets are the most accessible disinfection techniques with satisfactory microorganism reduction.

Oral fluids and disinfection procedures play important roles in the longevity of complete prostheses. There are many reports in published literature correlating thermocycling and disinfectant solutions with different properties of acrylic resin.[1,3,8,12,17,20-22] Yet, there are no known reports on the glaze polishing technique associated with acrylic resin for complete prostheses, considering the effect of thermocycling or disinfection procedures. Therefore, the aim of this study was to evaluate a photopolymerized glaze coating as a final polishing technique for pigmented complete prosthesis acrylic resins, under the influence of thermocycling and two disinfection procedures.

Materials and Methods

Two prosthesis heat cured acrylic resins (Onda Cryl, Classico LTDA, and Lucitone 550, Dentsply) and a purple characterization pigment (Policor, Classico LTDA) were used in the present study to evaluate a surface polishing technique. Two polishing techniques were applied: the mechanical as a control and a photopolymerized glaze coat. The clinical use through disinfection was also simulated, and the samples were submitted to two disinfection methods, either by microwave energy or immersion in cleaning tablets (Efferdent).

Two hundred and eight circular specimens (10 mm in diameter and 3 mm thick) were manufactured and divided into 16 groups. One hundred and sixty samples were used for the hardness, surface roughness, color stability, and surface energy analyses ($n = 10$), and 48 for atomic force microscopy (AFM) and MEV images ($n = 1$). One hundred and four were used for each type of resin, varying the pigmentation (52 samples were pigmented) and the polishing technique (52 were mechanically polished and 52 received a glaze coat).

A perforated metallic matrix was cast inside prosthesis flasks with type IV dental stone. The acrylic resins were weighted and manipulated according to the manufacturer's instructions. Six percent of the resin powder total weight in pigments were added to the pigmented groups during the manipulation, then the mix was inserted into the metallic matrix, and the curing cycle was initiated after a 30 min interval. The Lucitone 550 flasks were put in a hot water bath at 73°C for 90 min and immediately after, in boiling water for 30 min. The Onda Cryl specimens were microwave cured for 10 min (3 min at 30% power, 4 min at 0% power, and 3 min at 60% power).

After the flasks had cooled, the specimens were removed from the metallic matrix and the excess trimmed with tungsten burs. They were then polished with a sandpaper sequence (grit 600 and 800) under constant water irrigation in a universal polishing machine at 300 rpm (Ecomet 300pro; Buehler, Illinois, USA). The thickness of the specimens was regularly measured with a digital caliper (500-171-20b, Mitutoyo, Tokyo, Japan) to standardize their size.[6]

The mechanical polish samples were then submitted to 1200 grit sandpaper and a diamond solution on felt disc. The glaze finished groups received a uniform layer of Megaseal glaze (Megadenta, Radeberg, Germany) on the surface of the samples, and were then photopolymerized for 180s by a strobe light (EDG Equipment, Sao Carlos, Brazil). When both polishing techniques were complete, the specimens were sonicated in distilled water for 20 min to eliminate possible surface debris. All samples were then immersed in distilled water at 37°C for 24 h before the first testing period (T0). The tests were repeated after the disinfection (T1).[6]

The specimens remained immersed in distilled water in hermetically sealed containers at a controlled temperature of 35°C ± 2°C for 60 days, during which the disinfection was conducted. The selected groups were disinfected every 3 days, either by microwave energy or immersion in disinfection tablets. The Efferdent group was immersed in 250 ml of warm water with the effervescent tablet for 15 min, according to the manufacturer's instructions, and the microwave groups were immersed in 200 ml of distilled water and microwaved at 650W of radiation for 6 min.

The specimens were submitted to color stability, surface hardness, surface roughness (Rt), and wettability analysis. To evaluate the effects of the polishing techniques on the surface of the prosthesis base resins, one specimen of each group was selected and tested with scanning electron microscopy (SEM) and AFM.

Color alterations were calculated with the L*a*b* system, established by the Commission Internationale de l'Eclairage, in an ultraviolet-visible reflection spectrophotometer (model UV-2450, Shimadzu Corporation, Kyoto, Japan). Knoop microhardness was determined according to the American Society for Testing and Materials specification E384-1128, using a microhardener (HMV-2T; Shimadzu Corporation) with a 25 g load for 10 s. Surface roughness evaluation (Rt values) was performed through profilometry with a Surtronic 25 (Taylor Hobson) profilometer calibrated with a cutoff filter of 500 µm, an evaluation length of 1.25 mm, and a range of 100 mm.

The surface wettability was evaluated through surface energy analysis of the acrylic disks. The sessile drop technique was used in a temperature-controlled room, and ten measurements were repeated per specimen. Drops of 2 liquids with different polarities, deionized water, which represents polar components, and diiodomethane, featuring dispersive elements, were deposited in a controlled manner on the specimen surface, and then placed horizontally on a goniometer (Ramé-Hart 100-00; Ramé-Hart Instrument Co). Through software (DROPimage Standard; Ramé-Hart Instrument Co), the contact angle formed between the drop of each liquid to the acrylic resin was measured. The calculation of surface energy was performed according to the Owens-Wendt-Rabel-Kaelble method.[23]

Statistical analysis

The IBM SPSS 20.0 (IBM, United States) was used to assess the effects of different types of acrylic resin, the polishing technique applied, the period of evaluation, and the presence of pigment, were submitted to the analysis of variance (ANOVA). Significant differences were compared by the Tukey HSD test ($\alpha = 0.05$).

Results

Color stability

The ANOVA analysis presented a significant difference for the pigment × polish interaction [Table 1]. The Student's *t* post-test analysis showed that the glaze polished groups presented inferior chromatic stability [Table 2].

Table 3 indicates that the glaze polished groups without pigment presented a statistical difference regarding chromatic stability, while the glaze polished with pigment group presented the higher ΔE results.

Surface roughness (Rt)

In contrast to color stability, the hardness, and all subsequent analyses had two periods of evaluation (T0 - baseline, T1 - disinfection). Table 4 demonstrates that the polish, disinfection, and period factors, and the interactions of resin × disinfection, polish × disinfection, period × polish, period × resin × polish, period × pigment × disinfection, period × polish × disinfection statistically interfered in the roughness results.

The glaze polished groups presented higher surface roughness results and the disinfection increased the roughness, with the Efferdent group presenting higher roughness values [Table 5].

Surface hardness

The variables that presented a significant difference for surface hardness were period, polish, resin, and the interactions of resin × polish, period × polish and period × resin × pigment [Table 6]. Table 7 presents the ANOVA results for the surface hardness. Table 8 indicates that Lucitone presented higher hardness results than Onda Cryl, and demonstrates that the glaze polished groups had higher hardness values. There was a decrease in hardness after disinfection for both polishing techniques and resins, and the glaze polish maintained higher hardness values even after the disinfection period [Table 9].

Surface energy

Table 10 presents the ANOVA results for the surface energy assay. It was observed that the period and disinfection factors, as well as the interactions of resin × polish × disinfection,

Table 1: Analysis of variance results for the chromatic changes (ΔE)

Variation	SS	df	MS	*F*	*P*
Resin	1.809	1	1.809	0.556	0.457
Pigment	3.531	1	3.531	1.086	0.299
Polish	59.034	1	59.034	18.154	<0.001*
Disinfection	9.413	1	9.413	2.895	0.091
Resin × pigment	3.600	1	3.600	1.107	0.294
Resin × polish	1.057	1	1.057	0.325	0.569
Resin × disinfection	0.181	1	0.181	0.056	0.814
Pigment × polish	23.778	1	23.778	7.312	0.008*
Pigment × disinfection	0.012	1	0.012	0.004	0.952
Polish × disinfection	0.076	1	0.076	0.023	0.879
Resin × pigment × polish	1.638	1	1.638	0.504	0.479
Resin × pigment × disinfection	0.306	1	0.306	0.094	0.760
Resin × polish × disinfection	1.587	1	1.587	0.488	0.486
Pigment × polish × disinfection	1.178	1	1.178	0.362	0.548
Resin × pigment × polish × disinfection	1.650	1	1.650	0.507	0.477
Error	468.270	144	3.252		
Total	2047.044	160			

*$P<0.05$ means statistical difference. SS: Sum of square, MS: Mean of square

Table 2: Mean values and standard deviation of color change (ΔE) according to the polish, independent of resin, pigment and disinfection

Polish	Color change
Mechanic	2.42 (1.72)^{B}
Glaze	3.64 (1.90)^{A}

Means followed by the same capital letter in the column do not difference ($P<0.05$, Student *t*-test)

Table 3: Mean values and standard deviation of color change (ΔE) according to polish and pigments

Pigment	Mechanic	Glaze
Without pigment	2.19 (1.83)^{A,b}	4.17 (1.84)^{A,b}
With pigment	2.66 (1.59)^{A,b}	3.10 (1.81)^{B,a}

Means followed by the same capital letter in the column and the same lowercase letter in the line do not difference ($P<0.05$, Tukey)

Table 4: Analysis of variance results for the surface roughness

Variation	SS	df	MS	*F*	*P*
Resin	1.724	1	1.724	3.103	0.080
Pigment	0.211	1	0.211	0.379	0.539
Polish	9.038	1	9.038	16.263	<0.001*
Disinfection	4.355	1	4.355	7.836	0.006*
Resin × pigment	0.015	1	0.015	0.027	0.869
Resin × polish	0.013	1	0.013	0.024	0.877
Resin × disinfection	3.797	1	3.797	6.833	0.010*
Pigment × polish	1.515	1	1.515	2.726	0.101
Pigment × disinfection	0.543	1	0.543	0.977	0.325
Polish × disinfection	3.209	1	3.209	5.775	0.018*
Resin × pigment × polish	0.127	1	0.127	0.228	0.634
Resin × pigment × disinfection	1.137	1	1.137	2.045	0.155
Resin × polish × disinfection	0.010	1	0.010	0.017	0.896
Pigment × polish × disinfection	0.108	1	0.108	0.194	0.660
Resin × pigment × polish × disinfection	0.004	1	0.004	0.008	0.929
Between samples	80.026	144	0.556		
Period	7.531	1	7.531	10.524	0.001*
Period × resin	1.452	1	1.452	2.029	0.156
Period × pigment	0.799	1	0.799	1.117	0.292
Period × polish	3.292	1	3.292	4.601	0.034*
Period × disinfection	0.970	1	0.970	1.355	0.246
Period × resin × pigment	0.102	1	0.102	0.143	0.706
Period × resin × polish	6.084	1	6.084	8.502	0.004*
Period × resin × disinfection	0.525	1	0.525	0.733	0.393
Period × pigment × polish	2.101	1	2.101	2.936	0.089
Period × pigment × disinfection	6.107	1	6.107	8.535	0.004*
Period × polish × disinfection	3.647	1	3.647	5.096	0.025*
Period × resin × pigment × polish	0.750	1	0.750	1.048	0.308
Period × resin × pigment × disinfection	0.656	1	0.656	0.917	0.340
Period × resin × polish × disinfection	1.555	1	1.555	2.173	0.143
Period × pigment × polish × disinfection	0.745	1	0.745	1.040	0.309
Period × resin × pigment × polish × disinfection	1.267	1	1.267	1.771	0.185
Inter samples	103.048	144	0.716		

*P<0.05 means statistical difference. SS: Sum of square, MS: Mean of square

Table 5: Mean values and (standard deviation) of surface roughness with according to the polish, independent of resin, pigment, disinfection period

Polish	Roughness
Mechanic	2.06 (0.83)^{B}
Glaze	2.40 (0.89)^{A}

Means followed by the same capital letter in the column do not difference (P<0.05, Student *t*-test)

period × resin × pigment, period × resin × polish, period × resin × disinfection, period × pigment × polish, period × polish × disinfection, period × resin × pigment × polish, period × pigment × polish × disinfection and period × resin × pigment × polish × disinfection, were statistically significant.

It was observed that there was an increase of the surface energy after the disinfection (period) and that the Efferdent disinfection promoted higher surface energy values [Table 11].

Discussion

The null hypothesis that the polishing technique would not affect the mechanical properties of prosthesis acrylic resins was not accepted, since the glaze polish presented poor characteristics after the disinfection process.

Chromatic changes can be related to extrinsic and intrinsic factors.[7,18-22] These changes can also be related to polymer degradation during the aging process due to temperature changes and humidity,[8] or the exposure to chemical products during disinfection. It was observed that the groups polished by glaze presented more color changes than the mechanical polished groups.

There are still controversies regarding the color stability parameters. Canadas *et al.*,[24] Goiato *et al.* (2013),[20] and Mundim *et al.*[25] stated that chromatic changes (ΔE) superior to 3.3 are clinically unacceptable, whereas other authors established this value at 3.715. All groups in this study presented visually perceptible chromatic changes, and the glaze polishing presented the most clinically unacceptable ΔE [Table 2].

The glaze behaves differently from the resin when submitted to different disinfectant solutions. Different studies also reported color change of acrylic resin when submitted to different cleansing solutions.[26,27] Both disinfection methods were performed at an elevated temperature, which could induce an additional monomer release that could interact with the glaze coat, thus, increasing the chromatic alteration [Table 2]. The period of use can alter or remove this external coating,[28] but it is believed that the glaze underwent a chemical reaction from the increased temperature or disinfection methods.

The pigment addition also influenced the ΔE, and prevented the color change for the group polished by glaze [Table 3]. Goiato *et al.* (2013)[20] also found that the pigment addition at a concentration of 7% reduced the color alteration for the acrylic resin. The purple pigment used in the present study contains titanium in its composition, which is used in the formula of many sunscreen solutions because of its protective properties.[20]

The composition of the acrylic resin and built-up substances can also influence the color stability, especially if the surface roughness is elevated.[8,28,29] The exposure to moisture during the manipulation process, or the incorrect polymerization cycle, can lead to greater porosity, compromising the physical

Table 6: Mean values and (standard deviation) of surface roughness with different polishing techniques in different periods and disinfection methods

Polish	Disinfection	Initial	Final
Mechanic	Microwave	1.75 (0.57)^{A,a}	1.94 (0.65)^{B,a}
	Efferdent	1.86 (0.65)^{A,a}	2.70 (1.04)^{A,a}
With glaze	Microwave	2.28 (0.70)^{A,a}	2.49 (1.03)^{A,a}
	Efferdent	2.42 (0.92)^{A,a}	2.42 (0.91)^{A,a}

Means followed by the same capital letter in the column do not difference (P<0.05, Tukey). Means followed by the same lowercase letter in line do not difference (P<0.05, Tukey)

Table 7: Analysis of variance results for the surface hardness

Variation	SS	df	MS	*F*	*P*
Resin	1499.421	1	1499.421	94.551	<0.001*
Pigment	48.943	1	48.943	3.086	0.081
Polish	17914.402	1	17,914.402	1129.654	<0.001*
Disinfection	0.248	1	0.248	0.016	0.901
Resin × pigment	1.557	1	1.557	0.098	0.754
Resin × polish	1396.761	1	1396.761	88.078	<0.001*
Resin × disinfection	9.746	1	9.746	0.615	0.434
Pigment × polish	0.178	1	0.178	0.011	0.916
Pigment × disinfection	17.647	1	17.647	1.113	0.293
Polish × disinfection	1.685	1	1.685	0.106	0.745
Resin × pigment × polish	13.580	1	13.580	0.856	0.356
Resin × pigment × disinfection	4.685	1	4.685	0.295	0.588
Resin × polish × disinfection	0.013	1	0.013	0.001	0.977
Pigment × polish × disinfection	26.190	1	26.190	1.651	0.201
Resin ×pigment × polish × disinfection	1.429	1	1.429	0.090	0.764
Entre amostras	2283.596	144	15.858		
Period	250.597	1	250.597	11.440	0.001*
Period × resin	13.276	1	13.276	0.606	0.438
Period × pigment	12.356	1	12.356	0.564	0.454
Period × polish	523.896	1	523.896	23.917	<0.001*
Period × disinfection	44.119	1	44.119	2.014	0.158
Period × resin × pigment	214.163	1	214.163	9.777	0.002*
Period × resin × polish	2.470	1	2.470	0.113	0.738
Period × resin × disinfection	23.773	1	23.773	1.085	0.299
Period × pigment × polish	26.343	1	26.343	1.203	0.275
Period × pigment × disinfection	12.398	1	12.398	0.566	0.453
Period × polish × disinfection	0.005	1	0.005	<0.001	0.988
Period × resin × pigment × polish	52.856	1	52.856	2.413	0.123
Period × resin × pigment × disinfection	7.385	1	7.385	0.337	0.562
Period × resin × polish × disinfection	0.588	1	0.588	0.027	0.870
Period × pigment × polish × disinfection	43.454	1	43.454	1.984	0.161
Period × resin × pigment × polish × disinfection	6.138	1	6.138	0.280	0.597
Intra amostras	3154.226	144	21.904		

*P<0.05 means statistical difference. SS: Sum of square, MS: Mean of square

and esthetical properties of the resin. Therefore, color stability can be enhanced by lower surface roughness and intrinsic porosity.[28] The glaze groups presented worse roughness results, which corroborates with the color stability results.

Table 8: Mean values and (standard deviation) of hardness for each resin and polish

Resin	Mechanic	Glaze
Onda Cryl	20.54 (2.18)^{A,b}	31.33 (5.12)^{B,a}
Lucitone	24.69 (4.29)^{B,b}	39.84 (6.05)^{A,a}

Means followed by the same capital letter in the column do not difference (*P*<0.05, Tukey). Means followed by the same lowercase letter in line do not difference (*P*<0.05, Tukey)

Table 9: Mean values and (standard deviation) of hardness for each period and polishing technique

Period	Mechanic	Glaze
Initial	20.22 (4.16)^{A,b}	37.75 (7.31)^{A,a}
Final	21.01 (2.36)^{A,b}	33.42 (6.05)^{B,a}

Means followed by the same capital letter in the column do not difference (*P*<0.05, Tukey). Means followed by the same lowercase letter in line do not difference (*P*<0.05, Tukey)

Surface roughness is a characteristic directly dependent on the finishing and polishing techniques.[14] Therefore, the roughness parameter (Rt) was also assessed to clarify whether the surface treatment, glaze or mechanical, could influence the structural properties of acrylic resins. The glaze polish aims to even out the surface of the material, but some of the glaze polishing groups presented higher roughness values [Table 5], suggesting that the glaze surface in not as smooth as expected.[8,12,28]

On the other hand, the glaze maintained the initial roughness properties better, even after the disinfection, suggesting that it is a more stable polish than the sandpaper sequence [Table 6]. The roughness of the mechanically polished samples disinfected with Efferdent increased, and the SEM and AFM images illustrate the surface degradation [Figure 2]. The glaze polish prevented the surface degradation, suggesting that this polish forms a protective superficial coat.

Table 10: Analysis of variance results for the surface energy

Variation	SS	df	MS	*F*	*P*
Resin	7.385	1	7.385	0.805	0.371
Pigment	13.121	1	13.121	1.431	0.234
Polish	22.261	1	22.261	2.428	0.121
Disinfection	105.764	1	105.764	11.536	0.001*
Resin × pigment	327.451	1	327.451	35.717	<0.001*
Resin × polish	172.922	1	172.922	18.862	<0.001*
Resin × disinfection	0.782	1	0.782	0.085	0.771
Pigment × polish	129.999	1	129.999	14.180	<0.001*
Pigment × disinfection	0.042	1	0.042	0.005	0.946
Polish×disinfection	5.292	1	5.292	0.577	0.449
Resin × pigment × polish	0.369	1	0.369	0.040	0.841
Resin × pigment × disinfection	1.075	1	1.075	0.117	0.733
Resin × polish × disinfection	58.006	1	58.006	6.327	0.013*
Pigment × polish × disinfection	0.644	1	0.644	0.070	0.791
Resin × pigment × polish × disinfection	0.953	1	0.953	0.104	0.748
Between samples	1320.188	144	9.168		
Period	398.399	1	398.399	50.283	<0.001*
Period × resin	21.311	1	21.311	2.690	0.103
Period × pigment	0.668	1	0.668	0.084	0.772
Period × polish	3.210	1	3.210	0.405	0.525
Period × disinfection	41.657	1	41.657	5.258	0.023*
Period × resin × pigment	123.997	1	123.997	15.650	<0.001*
Period × resin × polish	175.501	1	175.501	22.151	<0.001*
Period × resin × disinfection	188.158	1	188.158	23.748	<0.001*
Period × pigment × polish	461.713	1	461.713	58.274	<0.001*
Period × pigment×disinfection	6.030	1	6.030	0.761	0.384
Period × polish × disinfection	147.627	1	147.627	18.632	<0.001*
Period × resin × pigment × polish	180.392	1	180.392	22.768	<0.001*
Period × resin × pigment × disinfection	11.237	1	11.237	1.418	0.236
Period × resin × polish × disinfection	0.009	1	0.009	0.001	0.973
Period × pigment × polish × disinfection	825.382	1	825.382	104.174	<0.001*
Period × resin × pigment × polish × disinfection	62.276	1	62.276	7.860	0.006*
Intra samples	1140.927	144	7.923		

**P*<0.05 means statistical difference. SS: Sum of square, MS: Mean of square

It is important that the surface of acrylic resin used to manufacture prostheses be free of irregularities, to avoid bacterial colonization and injuries to the underlying tissues that could lead to inflammation of the oral cavity of the patient.[8,24] An even surface cannot always be maintained; it depends on storage conditions and the cleaning habits of the patient. When not ideal, these can cause damage and scratches to the surface that facilitates bacterial growth, and harms the esthetics and longevity of the prosthesis.[5]

The microwave disinfection did not affect the roughness results for either polishing techniques, whereas the Efferdent increased the results for the mechanical polish [Table 6]. The manufacturer reports that the Efferdent tablets promote oxygen release to reduce debris and light stains on the surface. This procedure might have a deleterious effect on the surface, causing hydrolysis and decomposition of the resin, reducing the hardness, and increasing the surface roughness.[12]

Another property related to the longevity of prostheses is the surface hardness of the acrylic resin; greater hardness indicates higher resistance to abrasives and wear.[5,12,30] There was a difference in surface hardness between the brands evaluated. Lucitone 550 presented significantly higher results than Onda-Cryl [Table 8]. These results were possibly influenced by the material composition and the higher molecular weight of the resin.[3,5,31]

The groups polished by glaze presented higher surface hardness values, but this difference was not maintained after the disinfection. Although the glaze results remained higher than the mechanical polish, there was a decrease in the hardness values after the disinfection [Table 9]. Braun *et al*.[21] found that the mechanical polish had better hardness results than the chemical polish,[21] but the chemical polish in their study was performed through the immersion of the acrylic resin in a heated monomer.

Table 11: Mean values and (standard deviation) of surface energy for period and disinfection

Period	Microwave	Efferdent
Initial	$37.28 (5.02)^{B,b}$	$39.15 (3.97)^{B,a}$
Final	$40.23 (3.96)^{A,a}$	$40.66 (3.43)^{A,a}$

Means followed by the same capital letter in the column do not difference (*P*<0.05, Tukey). Means followed by the same lowercase letter in line do not difference (*P*<0.05, Tukey)

According to Fernandes *et al*.,[5] the surface hardness of acrylic resin should be between 16 and 22 KHN, since higher values impede the occurrence of cracks, reducing microbial colonization. The results of the current study are within these values, and the glaze polish presented hardness values ≥33 KHN even after the disinfection, suggesting that its protective coat improved the hardness properties of the acrylic resin. This could increase the longevity of prostheses polished by this solution.

The polish did not affect the surface energy results, only the disinfection and period did [Table 10]. The samples presented lower wettability before the disinfection assay, and the microwave disinfection increased the surface energy results. The lower the surface energy, the greater the adherence and biofilm accumulation.[15] Thus, the disinfection, especially using microwaves, proved to increase the surface resistance to biofilm accumulation.

The SEM and AFM images presented a surface difference for the polishes in the initial period, in which the glaze surface was smoother[28] but there was no difference between the resins tested [Figure 1]. The disinfection considerably degraded the surface integrity; There was a difference on the surface in the initial period [Figure 1] and after the disinfection [Figures 2 and 3], especially for the Efferdent disinfection [Figure 2].

The study limitations were that only one type of chemical polish was tested. There are new materials manufactured for this purpose, and more disinfection procedures could be applied. There are still some controversies regarding the glaze polish and further studies should be performed to validate

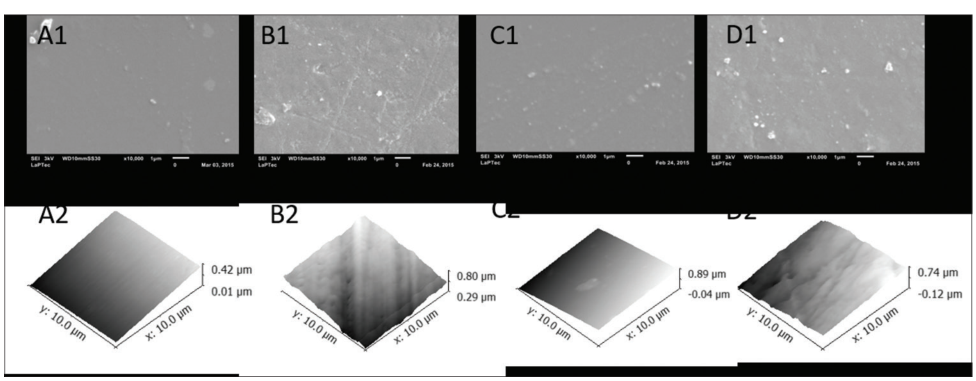

Figure 1: A1, AFM image of Onda Cryl acrylic resin with photopolymerized glaze. B1, MEV image of Onda Cryl acrylic resin with photopolymerized glaze. C1, AFM image of Onda Cryl acrylic resin without photopolymerized glaze. D1, MEV image of Onda Cryl acrylic resin without photopolymerized glaze. A2, AFM image of Lucitone acrylic resin with photopolymerized glaze. B2, MEV image of Lucitone acrylic resin with photopolymerized glaze. C2, AFM image of Lucitone acrylic resin without photopolymerized glaze. D2, MEV image of Lucitone acrylic resin without photopolymerized glaze. AFM: Atomic force microscopy

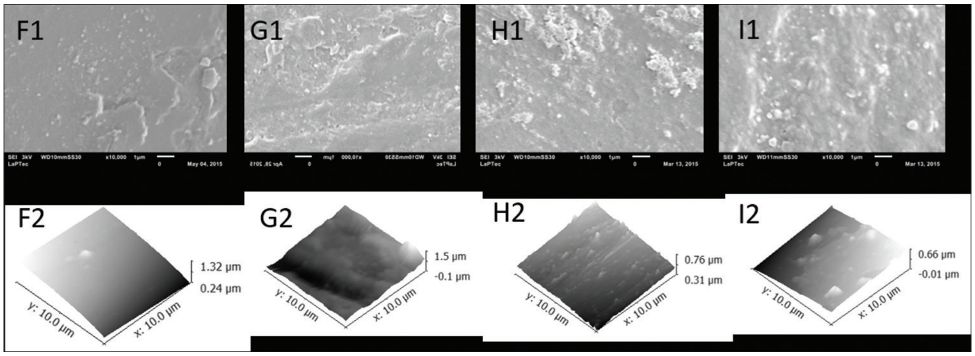

Figure 2: F1, AFM image of Onda Cryl acrylic resin with glaze - Efferdent. G1, MEV image of Onda Cryl acrylic resin with glaze - Efferdent. H1, AFM image of Onda Cryl acrylic resin without glaze-Efferdent. I1, MEV image of Onda Cryl acrylic resin without glaze - Efferdent. F2, AFM image of Lucitone acrylic resin with glaze - Efferdent. G2, MEV image of Lucitone acrylic resin with glaze - Efferdent. H2, AFM image of Lucitone acrylic resin without glaze - Efferdent. I2, MEV image of Lucitone acrylic resin without glaze - Efferdent. AFM: Atomic force microscopy

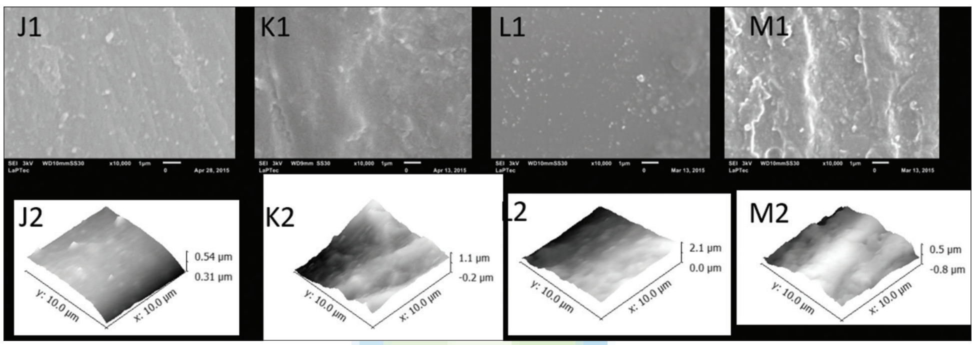

Figure 3: J1, AFM image of Onda Cryl acrylic resin with glaze - Microwave Energy. K1, MEV image of Onda Cryl acrylic resin with glaze - Microwave Energy. L1, AFM image of Onda Cryl acrylic resin without glaze - Microwave Energy. M1, MEV image of Onda Cryl acrylic resin without glaze - Microwave Energy. J2, AFM image of Lucitone acrylic resin with glaze - Microwave Energy. K2, MEV image of Lucitone acrylic resin with glaze - Microwave Energy. L2, AFM image of Lucitone acrylic resin without glaze - Microwave Energy. M2, MEV image of Lucitone acrylic resin without glaze - Microwave Energy. AFM: Atomic force microscopy

its clinical use, such as toxicity to the oral tissues, since the material was first developed for provisional restorations and there no records of long term use.

This study evaluated the disinfection effect on mechanical properties of the resin, future research could evaluate the same groups for antimicrobial effect of different disinfection solutions on the different polishing techniques or to evaluate the microorganism adhesion on the surface of the glaze polish tested. Furthermore, clinical tests could be performed to assess further information on this new polish.

Conclusion

Based on the results of this study, the photopolymerized glaze improved most characteristics of the acrylic resin, such as the surface hardness and roughness, but did not affect the surface wettability. The absence of characterization pigments in the acrylic resin is inadequate for color stability. When the mechanical properties are considered, the microwave disinfection method promoted better results than the Efferdent tablets.

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Conflicts of interest

There are no conflicts of interest.

References

1. Lai CP, Tsai MH, Chen M, Chang HS, Tay HH. Morphology and properties of denture acrylic resins cured by microwave energy and conventional water bath. Dent Mater 2004;20:133-41.
2. Goiato MC, Zuccolotti BC, Haddad MF, Moreno A, Pesqueira AA, Gennari HF, *et al.* The effect of disinfection techniques on the flexural strength of thermopolymerisable acrylic resins with or without pigment addition. Eur J Prosthodont Restor Dent 2015;23:193-8.
3. Goiato MC, dos Santos DM, Moreno A, Iyda MG, Rezende MC, Haddad MF, *et al.* Effect of disinfection and storage on the flexural strength of ocular prosthetic acrylic resins. Gerodontology 2012;29:e838-44.
4. Cakan U, Kara HB. Effect of liquid polishing materials on the stainability of bis-acryl interim restorative material *in vitro*. J Prosthet Dent 2015;113:475-9.
5. Fernandes AU, Goiato MC, dos Santos DM. Effect of weathering and thickness on the superficial microhardness of acrylic resin and ocular button. Cont Lens Anterior Eye 2009;32:283-7.

6. Goiato MC, Dos Santos DM, Baptista GT, Moreno A, Andreotti AM, Bannwart LC, *et al.* Effect of thermal cycling and disinfection on colour stability of denture base acrylic resin. Gerodontology 2013;30:276-82.
7. Goiato MC, Dos Santos DM, Baptista GT, Moreno A, Andreotti AM, Dekon SF, *et al.* Effect of thermal cycling and disinfection on microhardness of acrylic resin denture base. J Med Eng Technol 2013;37:203-7.
8. Kuhar M, Funduk N. Effects of polishing techniques on the surface roughness of acrylic denture base resins. J Prosthet Dent 2005;93:76-85.
9. Santos DM, Commar BC, da Rocha Bonatto L, da Silva EV, Sônego MV, Rangel EC, *et al.* Surface characterization of polymers used in fabrication of interim prostheses after treatment with photopolymerized glaze. Mater Sci Eng C Mater Biol Appl 2017;71:755-63.
10. Santos DM, Nagay BE, da Silva EV, Bonatto Lda R, Sonego MV, Moreno A, *et al. In vitro* analysis of different properties of acrylic resins for ocular prosthesis submitted to accelerated aging with or without photopolymerized glaze. Mater Sci Eng C Mater Biol Appl 2016;69:995-1003.
11. Rao DC, Kalavathy N, Mohammad HS, Hariprasad A, Kumar CR. Evaluation of the surface roughness of three heat-cured acrylic denture base resins with different conventional lathe polishing techniques: A comparative study. J Indian Prosthodont Soc 2015;15:374-80.
12. Moreno A, Goiato MC, dos Santos DM, Haddad MF, Pesqueira AA, Bannwart LC, *et al.* Effect of different disinfectants on the microhardness and roughness of acrylic resins for ocular prosthesis. Gerodontology 2013;30:32-9.
13. Silva MJ, de Oliveira DG, Marcillo OO, Neppelenbroek KH, Lara VS, Porto VC, *et al.* Effect of denture-coating composite on *Candida albicans* biofilm and surface degradation after disinfection protocol. Int Dent J 2016;66:86-92.
14. Gungor H, Gundogdu M, Yesil Duymus Z. Investigation of the effect of different polishing techniques on the surface roughness of denture base and repair materials. J Prosthet Dent 2014;112:1271-7.
15. Haralur SB. Evaluation of efficiency of manual polishing over autoglazed and overglazed porcelain and its effect on plaque accumulation. J Adv Prosthodont 2012;4:179-86.
16. Hamedi Rad F, Ghaffari T, Tamgaji R. Evaluation of the color stability of methyl methacrylate and nylon base polymer. J Dent (Shiraz) 2017;18:136-42.
17. Shinawi LA. Effect of denture cleaning on abrasion resistance and surface topography of polymerized CAD CAM acrylic resin denture base. Electron Physician 2017;9:4281-8.
18. Lohitha K, Prakash M, Gopinadh A, Sai Sankar AJ, Sandeep CH, Sreedevi B, *et al.* Color stability of heat-cure acrylic resin subjected to simulated short-term immersion in fast-acting denture cleansers. Ann Med Health Sci Res 2016;6:291-5.
19. Gandhi N, Daniel S, Benjamin S, Kurian N, Varghese VS. Evaluation of surface microhardness following chemical and microwave disinfection of commercially available acrylic resin denture teeth. J Clin Diagn Res 2017;11:ZC87-91.
20. Goiato MC, Zuccolotti BC, dos Santos DM, Sinhoreti MA, Moreno A. Effect of intrinsic nanoparticle pigmentation on the color stability of denture base acrylic resins. J Prosthet Dent 2013;110:101-6.
21. Braun KO, Mello JA, Rached RN, Del Bel Cury AA. Surface texture and some properties of acrylic resins submitted to chemical polishing. J Oral Rehabil 2003;30:91-8.
22. Rao DC, Kalavathy N, Mohammad HS, Hariprasad A, Kumar CR. Evaluation of the surface roughness of three heat-cured acrylic denture base resins with different conventional lathe polishing techniques: A comparative study. J Indian Prosthodont Soc 2015;15:374-80.
23. Ferracane JL. Hygroscopic and hydrolytic effects in dental polymer networks. Dent Mater 2006;22:211-22.
24. Canadas MD, Garcia LF, Consani S, Pires-de-Souza FC. Color stability, surface roughness, and surface porosity of acrylic resins for eye sclera polymerized by different heat sources. J Prosthodont 2010;19:52-7.
25. Mundim FM, Antunes PL, Sousa AB, Garcia LF, Pires-de-Souza FC. Influence of artificial accelerated ageing on the colour stability of paints used for ocular prosthesis iris painting. Gerodontology 2012;29:e312-7.
26. Goiato MC, Nóbrega AS, dos Santos DM, Andreotti AM, Moreno A. Effect of different solutions on color stability of acrylic resin-based dentures. Braz Oral Res 2014;28:1-7.
27. Freitas Oliveira Paranhos Hd, Bezzon OL, Davi LR, Felipucci DN, Silva CH, Pagnano VO, *et al*. Effect of cleanser solutions on the color of acrylic resins associated with titanium and nickel-chromium alloys. Braz Oral Res 2014;28:1-7.
28. Rutkunas V, Sabaliauskas V, Mizutani H. Effects of different food colorants and polishing techniques on color stability of provisional prosthetic materials. Dent Mater J 2010;29:167-76.
29. Gad MM, Fouda SM, ArRejaie AS and Al-Thobity AM. Comparative Effect of Different Polymerization Techniques on the Flexural and Surface Properties of Acrylic Denture Bases. Journal of Prosthodontics. 2017. doi:10.1111/jopr.12605.
30. Goiato MC, dos Santos DM, Gennari-Filho H, Zavanelli AC, Dekon SF, Mancuso DN, *et al.* Influence of investment, disinfection, and storage on the microhardness of ocular resins. J Prosthodont 2009;18:32-5.
31. Fernandes AU, Goiato MC, Dos Santos DM. Effect of weathering and thickness on roughness of acrylic resin and ocular button. Cont Lens Anterior Eye 2010;33:124-7.