

Effect of different polishing methods on surface roughness of provisional prosthetic materials

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Abstract

Purpose: To evaluate the surface roughness of bis-acrylic and acrylic resins submitted to different methods of polishing.

Materials and Methods: Fifty samples of each provisional restorative material (Structur 2, Protemp 4, Duralay, and Dencrilay) were fabricated (10 mm × 2 mm) and divided into five groups ($n = 10$): (1) positive control group – polyester strip; (2) negative control – unpolished; (3) abrasive tips (Exa-Technique-Edenta); (4) goat hair brush and diamond polishing paste; and (5) silicone tips (Enhance). Each material was mixed and polymerized according to manufacturer's instructions. The parameter evaluated was the arithmetic mean of the surface roughness (Ra) determined using the rugosimeter SJ 301 (Mitutoyo, Japan). The data were analyzed with two-way analysis of variance (*post hoc* Tukey's test) ($P < 0.05$).

Results: The lowest surface roughness values (0,22–0,90 μm) were observed in the Group 4 – goat hair brush and diamond paste, while the highest values (1,17–1,44 μm) were found in the Group 5 – silicone tips (enhance), with statistically significant differences between them, except for Dencrilay acrylic resin. There was statistically significant difference between bis-acrylic and acrylic resins in the Groups 1, 2, and 4.

Conclusions: Within the limitations of this study, it was concluded that the most effective polishing system was the goat hair brush with diamond paste for both bis-acrylic and acrylic resins. The bis-acrylic resins exhibited significantly smoother surfaces than the acrylic resins.

Keywords: Acrylic resins, dental materials, dental restoration, temporary

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INTRODUCTION

There are numerous rehabilitation treatment options with fixed prostheses. These can be total or partial, single or multiple, on teeth or implants. For each one, there are

steps before installation of the final prosthesis, with the provisional stage of great importance.^[1]

The provisional restorations are used for both the preparation and protection of the mechanical requirements

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and for the diagnosis of functional, occlusal, and esthetic parameters. In addition, the provisional restorations are used to predict the result of a more favorable treatment before treatment is concluded.^[1-3] Therefore, the provisional restorations must resemble the shape and function of the final treatment, keeping similar characteristics of natural teeth by size, position, color, cervical adaptation, and retention contour.^[1,2,4-7]

Temporary restorations in fixed prostheses are usually made from polymethyl methacrylate resins (acrylic) or bis-acrylate resins (bis-acryl), which have different characteristics and properties.^[7] The choice of material is usually based on the ease of handling, cost, working time, and esthetics.^[1,7]

Autopolymerizing acrylic resin is the most commonly used material due to its low cost, ease of handling, and rebasing and adjustment possibilities during the treatment.^[8] Moreover, this material is easily available in the dental market.^[1] However, it has higher exotherm values and a possibility of irritation and pulp damage associated with the residual monomer. Its biophysical properties are influenced by the powder-liquid ratio that can vary from one dentist to another.^[9]

The bis-acryl resins were introduced into the market as an alternative for provisional prosthesis confection and relining. When compared to acrylic resin, this new material has advantages, such as ease of handling (available in the form paste/paste that can be applied directly in the mouth with a self-mixer), setting time and significantly less labor, and low exotherm values.^[4,10,11]

The provisional prosthesis, however, can only properly perform its duties if it remains in the mouth the amount of time required for preparation of the final prosthesis and does not cause significant changes in oral tissues.^[12] In practice, the use of a provisional prosthesis may extend from a few days to one semester or more, indicating that a low quality of provisional restorations can bring complications, dissatisfaction, and even additional costs for its replacement.^[2,4,12] As a rule, the longer the material is exposed to various factors (diet, oral hygiene, water sorption, and chemical reactivity), the greater the chances for discoloration and increased roughness.^[7] As Borchers *et al.*^[13] indicated, when longer periods of service are intended, plaque prevention becomes increasingly important and more effective polishing of the interim restoration is necessary.

The biofilm accumulation on the provisional restorations is directly related to the roughness of their surfaces.^[8,12] These

materials must be polished before temporary cementation to obtain a surface with less bacterial adherence, reduce the potential for formation of caries and periodontitis lesions, and minimize the discoloration.^[4,6]

From the biological and cosmetic point of view, finishing and polishing procedures are considered essential for esthetics and obtaining smooth and polished prosthetics. The finishing of the restorations involves the removal of excess coarse material and the provision of an anatomical contour at the same time as the initiation of the surface smoothing process. The act of polishing constitutes a treatment on the surface using appropriate materials and techniques. Among the most commonly used systems are the silicone tips, abrasive tips of different particle sizes, and the use of chemical substances on the surface of the material.^[1,4,14]

A variety of methods are available on the market for polishing, which makes it difficult to decide which method would be the best system to use.^[4,8,10] The dentist needs to know and becomes familiar with the various materials and methods of finishing and polishing to enjoy all the associated benefits in clinical practice.

The aim of this study was to evaluate the surface roughness of bis-acrylic (Structur 2, Protemp 4) and acrylic resins (Duralay, Dencrilay) submitted to different polishing methods.

MATERIALS AND METHODS

Four provisional prosthetic materials were used (Structur 2, Protemp 4, Duralay, and Dencrilay). A total of 200 samples were fabricated: 50 samples of each material using circular stainless steel molds 10 mm in diameter and 2 mm high. Each material was mixed and polymerized according to manufacturer's instructions. The acrylic resin was inserted in a single increment in the mold. The insertion of bis-acrylic resins in the mold was achieved using the respective dispenser and self-mixer tips of each manufacturer. A polyester strip and a glass plate were placed over the stainless steel mold to promote removal of the excess and to ensure a flat and parallel surface, to facilitate the reading of the samples in the rugosimeter [Table 1].

After the curing period, the samples were removed. According to the manufacturers' recommendations, the samples of bis-acryl resins were subjected to rubbing with gauze that was soaked in alcohol (for removal of the inhibiting layer) for 20 s.

All the samples, except the positive control group (polyester strip), suffered previous finish with silicon carbide sandpaper (3M ESPE, São Paulo, Brazil) with grits P240, P320, and P360, for 20 s each, under cooling in polishing machine APL4 (AROTEC S/A Indústria e Comércio, Cotia, SP, Brazil) in order to standardize the initial surface smoothness of each sample and simulate a common condition in clinical practice. For this purpose, the samples were fixed with sticky wax (Asfer Indústria Química Ltda, SP, Brazil) in acrylic devices.

Subsequently, the samples of each material were divided into five groups ($n = 10$):

- G1-positive control group (polyester strip): The samples were fabricated only with the polyester strip
- G2-negative control (unpolished): The samples did not receive polishing (only finishing with the sandpapers)
- G3-abrasive tips Exa-Technique-Edenta (Labordental Ltda, São Paulo, SP, Brazil): The abrasive tips were used from the most coarse grained to the finest grained in a sequence as follows: green (coarse-grained finish), gray (average-grained, prepolishing), and yellow (fine-grained, polishing). Each tip was applied to the face of the sample for 20 s, with a rotation of 15,000 rpm (green and gray) and 7,000 rpm (yellow) according to manufacturer's instructions
- G4-goat hair brush and diamond polishing paste: The goat hair brush (Becht[®], Labordental Ltda, São Paulo, SP, Brazil) with the diamond polishing paste extra fine-grained 2–4 microns (Diamond Excel, Dentscare LTDA, Joinville-SC, Brazil) were used in a constant rotation of 18,000 rpm for 1 min
- G5-silicone tips Enhance: The silicone tips Enhance (Dentsply[®], Petrópolis, RJ, Brazil) were used for 30 s at a rotation of 10,000 rpm.

One operator polished all the specimens and a rag wheel was used to apply the polishing medium at the determined rotational speed. The specimens were polished in the same

orientation, and they were analyzed for surface roughness along the same orientation.

After polishing, each specimen was rinsed under distilled water and placed in an ultrasonic bath for 10 min. Average surface roughness (Ra) was measured at 3 locations (vertical, horizontal, and oblique directions) randomly on the surface of each specimen using the rugosimeter SJ 301 (Surface Roughness Tester, Mitutoyo, Japan).^[15] The device has a diamond stylus with a 0.5 μm radius in size moved at a constant speed of 0.5 mm/s. The cutoff was set at 0.8 mm, the distance was 4 mm, and the surface roughness was measured in micrometers (microns).

The data were checked to ensure their normality and homogeneity of variance by D'Agostino and Pearson test. Afterward, a two-way analysis of variance test was applied to the data. Specific differences within each restorative material and comparisons among polishing methods were performed using Tukey's test (significance level of 5%). The statistical calculations were carried out using the SPSS (SPSS Inc., Chicago, IL, USA).

RESULTS

According to Table 2, for both bis-acrylic resins, the lowest surface roughness values were observed in the Group 1 – positive control and Group 4 – goat hair brush, which showed no significant difference between them. The highest surface roughness values were found in the Group 5 – silicone tips (Enhance) which was statistically different from the other groups.

For the Duralay acrylic resin, the lowest roughness values were observed in the Group 4 – goat hair brush, but there was no statistically significant difference compared to Group 3 – abrasive tips. For the Dencrilay acrylic resin, there was no statistically significant difference among all groups.

There was statistically significant difference between bis-acrylic and acrylic resins on the Groups 1 – positive control, 2 – negative control, and 4 – goat hair brush. For the Group 3, the acrylic resin Duralay showed no statistically significant difference compared to bis-acrylic resins (Protemp 4 and Structur 2). There was no statistically significant difference among all resins on the Group 5.

DISCUSSION

In this study, the mean roughness values ranged from 0.22 to 1.62 microns. According to Bollen *et al.*,^[16] the Ra value that is clinically acceptable for a hard surface in the oral environment is 0.2 microns, above which an increase in

Table 1: Provisional prosthetic materials used in the study

Material	Composition	Manufacturer
Structur 2	Bis-GMA, BHT, amines, benzoyl peroxide, dimethacrylates, glass particles	Voco, Cuxhaven, Germany
Protemp 4	Dimethacrylate polymer. Bis-GMA, zirconium particles, silica and silane, pigments.	3M ESPE AG, Seefeld, Germany
Duralay	Copolymer of plasticizable methacrylate, methyl methacrylate monomer, paraffin, mineral oil	Reliance, Cotia-SP, Brazil
Dencrilay	Methyl methacrylate, butyl acrylate, benzoyl peroxide, ethylene glycol, pigments	Dencril, São Paulo-SP, Brazil

GMA: Glycidyl methacrylate, BHT: Butyl hydroxytoluene

Table 2: Mean and standard deviation of surface roughness of provisional prosthetic materials submitted to different methods of polishing

Variables	Group 1 (positive control)	Group 2 (negative control)	Group 3 (abrasive tips)	Group 4 (goat hair brush)	Group 5 (silicone tips)
Structur 2					
Mean	0.27 ^{A,a}	0.59 ^{B,a}	0.57 ^{B,a}	0.22 ^{A,a}	1.44 ^{C,a}
DP	0.07	0.08	0.17	0.08	0.28
Protemp 4					
Mean	0.25 ^{A,a}	0.40 ^{A,B,a}	0.55 ^{B,a}	0.24 ^{A,a}	1.27 ^{C,a}
DP	0.07	0.09	0.12	0.08	0.31
Duralay					
Mean	1.31 ^{A,b}	0.99 ^{B,b}	0.62 ^{C,a}	0.41 ^{C,b}	1.24 ^{A,a}
DP	0.98	0.11	0.05	0.06	0.43
Dencrilay					
Mean	1.62 ^{A,b}	1.44 ^{A,c}	1.19 ^{A,b}	0.90 ^{A,c}	1.17 ^{A,a}
DP	0.72	0,41	0.58	0.30	0.48

ANOVA two-way, Tukey test. Different letters, lowercase in columns and uppercase in rows, indicate statistically significant difference ($P < 0.05$).

ANOVA: Analysis of variance, SD: Standard deviation OBS: Need to change all DP in the table to SD

bacterial colonization occurs. This fact justifies the demand for smooth and glossy surfaces, whereas the higher the surface smoothness of a restorative material, the less the ability to provide the retention of microorganisms on its surface and therefore the formation of dental biofilm.

Studies showed that sufficiently polished surfaces could be obtained when the resins are polymerized in contact with the polyester matrix strips.^[10,17] For this reason, it was chosen as the positive control group. However, in clinical practice, during the step of prosthesis confection, the removal of coarse excesses and occlusal adjustments in the mouth are usually required, which promotes the increasing of roughness on the surface of the restorative materials. Therefore, the polishing of provisional restorations becomes necessary.

Korkmaz *et al.*^[18] used the negative control group to simulate the wear made by rotary instruments in the mouth (usually required for proximal and occlusal adjustments). In this study, the Group 2 – negative control (unpolished samples) showed values from 0.40 to 0.59 microns for the bis-acrylic resins and values from 0.99 to 1.44 microns for the acrylic resins. According to Table 2, a reduction in the surface roughness values after the use of polishing methods (goat hair brush and abrasive tips for majority of the materials) was observed, which justifies the need for polishing to reduce the surface roughness. The smooth surfaces make it difficult for the adherence and colonization of microorganisms, reduce the biofilm formation, and prevent local infections.

According to the manufacturer's instructions, the bis-acrylic resin Protemp 4 allows for dispensation of the polishing step because the rubbing with alcohol after polymerization is enough to provide a smooth surface; this action is responsible for the removal of the inhibition layer (layer not

polymerized in contact with oxygen). However, with the need to make adjustments, the polishing step becomes critical.

In this study, for both of the bis-acrylic resins, polishing with a goat hair brush and diamond paste resulted in lower values for surface roughness, which were similar to the positive control group (polyester strip). Similar results were found in the study by Rutkunas *et al.*,^[2] however, the goat hair brush was used with a mixture of pumice and water, which demonstrates that the mechanical polishing combined with polishing paste is a viable and beneficial technique because it results in less surface roughness. Sen *et al.*^[12] also reported that the polishing pastes promoted greater efficiency and generated more smooth surfaces in both bis-acrylic and acrylic resins. The same study stated that the diamond pastes had better results compared to aluminum oxide pastes.

The evaluated bis-acrylic resins showed higher roughness values in the Group 5 – silicone tips (Enhance system) [Table 2]. These results are in agreement with the study of Rutkunas *et al.*,^[4] demonstrating that this system should not be used as the first choice for polishing of these materials because the other polishing systems had significantly lower mean roughness values.

It was observed that the bis-acrylic resins (Protemp 4 and Structur 2) had similar surface roughness values and could be used within the same quality standard. These two provisional restorative materials have similar characteristics, both in its composition, as well as in handling and usage.

The fact that the Group 1 – positive control had an increase in roughness in the acrylic resins can be explained by their manipulation technique (powder-liquid). Despite being performed by the same operator and according to the manufacturer's instructions, embedding the resin in the

matrix may have caused the formation of bubbles and irregularities, resulting in a change in surface roughness.

The acrylic resin Dencrilay showed no statistically significant differences between the polishing systems and the positive and negative control groups. It is not clear what type of polishing would be the best to use with this material.

In this study, the lower surface roughness values were observed for the acrylic resin Duralay compared to Dencrilay. These results are in agreement with the studies of Braun *et al.*^[19] and Barbosa *et al.*,^[1] suggesting that this resin may possess differences in composition or in the particle size, which would account for the decrease in surface roughness values.

The bis-acrylic resins showed lower values of surface roughness compared to acrylic resins in the Groups 1, 2, and 4 [Table 2]. Young *et al.*^[9] and Ulker *et al.*^[20] stated that the bis-acrylic resins have gained popularity because of the ease of handling (convenience of the base-catalyst system, which results in more accurate ratios) and reduced exotherm and polymerization shrinkage. These innovations may have contributed to the lower roughness values of the bis-acryl resins.

However, these values differ from the studies of Sen *et al.*,^[12] Haselton *et al.*,^[6] and Rutkunas *et al.*,^[2] in which the roughness surface values of the acrylic resins were lower than the bis-acrylic resins. The authors explained this result by comparing the homogeneous composition of the acrylic material and the heterogeneous design of the bis-acryl composites. The size and distribution of the particles of the acrylic resins, the composition of the resin matrix, and the chemical nature of the material may influence polishing. According to Haselton *et al.*,^[6] this particularity in the distribution and size of the particles can respond positively to traditional polishing methods.

The care with the finishing and polishing of provisional prosthetic materials should be viewed as a fundamental step by the dentists. Thus, as the efficiency of the polishing increases, the probability of success increases. The close relationship between the surface smoothness and the reduction of bacterial adhesion, biofilm formation and consequent degradation of the dental and periodontal structure is well known.

CONCLUSIONS

The polishing method and the type of material used for fabricating provisional dental prostheses influence the

quality of the final prostheses. Within the limitations of this study, it was concluded that the most effective polishing system was the goat hair brush with diamond paste for both bis-acrylic and acrylic resins. The bis-acrylic resins exhibited significantly smoother surfaces than the acrylic resins.

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Conflicts of interest

There are no conflicts of interest.

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