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Evaluation of Surface Physical Properties of Acrylic Resins for Provisional Prosthesis

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Acrylic resins used for provisional prostheses should have satisfactory superficial characteristics in order to ensure gingival health and low bacterial attachment. The purpose of the present study was to evaluate the superficial roughness and contact angle after two types of polishing and the Vickers hardness of three acrylic resins (Duralay - G1, Dencrilay - G2, and Dencor - G3), all shade 66, indicated for provisional fixed prostheses. Five 20 x 3 ± 1 mm diameter discoid specimens were obtained for each group. One side of the specimens was subjected to standard polishing (pumice and whiting slurry), and the opposite side was polished with special tips. The mean roughness and contact angles of the materials were measured. The specimens were subjected to the Vickers microhardness test, which indicated that standard polishing produced a surface roughness equivalent to that of the special tips. The contact angles obtained with the standard polishing were equivalent to those observed in the special tips group. The microhardness of G1 and G3 resins showed statistical differences.

Keywords: *dental polishing, dental restoration, temporary, surface properties, hardness*

1. Introduction

In rehabilitation with fixed partial prostheses, provisional prostheses made of acrylic resins provide important conditions for gingival integrity and functional and aesthetic preservation for the patient. The surface characteristics of roughness, hardness and surface free energy affect the aesthetic appearance, color stability, preservation of intermaxillary relations, bacterial attachment and visible biofilm formation[1]. If the material and the technique are adequate, the final result will be satisfactory quality and, hence, integrity of dental supporting tissues.

The lack of attachment of dental bacterial plaque is essential for the success of provisional fixed prostheses, which in turn is an important factor in the success of definitive fixed prostheses, from the standpoint of gingival health the provisional prosthesis should ensure. Dental materials with rough surfaces have been found to favor bacterial attachment and hinder their removal by natural forces[2] or even by oral hygiene methods[3]. This finding has also been confirmed by Radford et al.[4] and Taylor et al.[5], who found greater bacterial attachment on rougher surfaces.

The surface roughness of provisional crowns depends on the type of acrylic resin employed, as well as the processing technique[6] and the type of surface polishing[7,8]. Differences in polishing techniques have been found to interfere in roughness[9,10,11]. Rahal et al.[10], who evaluated the effects of chemical and mechanical polishing on roughness in four types of acrylic resins used in prosthetic bases, found that mechanical polishing produced better results. Xavier et al.[12] also evaluated the effect of chemical and mechanical polishing on the surface roughness of three acrylic resins from different manufacturers and concluded that mechanical polishing produced the lowest roughness values, followed by the control group and by chemical polishing. Other studies indicate that different types of polishing interfere in roughness[13,14,15,16], and also lead to loss of dental material[17].

Surface energy, another physical property of material, is related with the contact angle formed in the presence of liquid on the surface[18]. It is also related to the amount of bacteria attached to the surface of the material. However, some authors[19,20] consider that the most relevant issue is the low surface roughness achieved by polishing[21].

With regard to provisional fixed prostheses, the preservation of the position of the prepared tooth and healthy periodontal tissues are indispensable. The surface microhardness can serve as a density indicator, and the denser the material the more resistant to deterioration its surface[22]. Therefore, in addition to the aforementioned properties, the surface property of microhardness was evaluated here as an indicator of the wear resistance of the materials under study[18].

Several studies have evaluated the surface roughness, contact angle and surface microhardness of dental materials. However, the literature lacks studies of these surface physical properties in acrylic resins used specifically in provisional prostheses. Furthermore, the importance of these characteristics underlines the need for studies comparing different brands, both national and imported, to provide dentists with criteria and a scientific basis upon which to make the best possible choice of the products to be used. Therefore, the purpose of this study was to evaluate the surface physical properties of acrylic resins used in provisional prostheses following the application of different polishing techniques.

2. Materials and Methods

2.1. Specimen fabrication

This study involved three self-curing acrylic resins for provisional prostheses: G1 - Duralay (Duralay, Reliance Dental Mfg. Co.,

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Chicago, EUA); G2 - Dencrilay (Dencril Com e Ind de Plasticos Ltda, Brazil); and G3 - Dencor (Clássico, São Paulo, Brazil), all of color number 66. For each group, five disk-shaped specimens measuring 20 x 3 ± 1 mm diameter were prepared and polymerized following the manufacturers' instructions.

2.2. Surface roughness measurements

The specimens were subjected to an initial surface roughness test (Ra - µm) to determine the initial parameter for comparison. They were then finished with 150 to 600 grit waterproof sandpaper under flowing water (Aropol E. Arotec, SP, Brazil) at a standard speed of 300 rpm until they reached a thickness of 3.0 ± 1.0 mm. One of the surfaces was machine polished with pumice and water, followed by whiting slurry with polishing cloths (conventional or standard polishing) and the other side was polished with special tips (Tec®, São Paulo, Brazil). The specimens were then measured with a profile meter (Mitutoyo® - Surf Test 301) calibrated for a 0.25 mm sample surface. The roughness of each specimen was measured twice and the mean value recorded.

2.3. Contact angle measurements

To measure the contact angles, each specimen was wetted with 10 µl of distilled water applied with a micropipette from a standard height of 2 cm above the polished surface. At this point, photographic records were made in triplicate using a digital camera (Sony Cybershot DSC – F717) situated at a distance of 20 cm from the pipette tip, and the images were analyzed with the Image Tool 3.0 UTHSCSA program.

2.4. Vickers hardness measurements

The Vickers hardness (VHN) was measured with a microhardness tester (HMV Shimadzu, Tokio, Japan), with a 0.1 N indenter load/15 seconds. Eight microhardness measurements were taken from each specimen.

3. Statistical Analysis

The surface roughness and contact angle data were subjected separately to two-way ANOVA ($\alpha = 0.05$) and Tukey ($\alpha = 0.05$) tests to compare the results of each acrylic resin brand and polishing condition. The Vickers hardness was analyzed by one-way ANOVA ($\alpha = 0.05$) and Tukey's ($\alpha = 0.05$) test to compare the results of each acrylic resin brand.

4. Results

Figure 1 depicts the mean values and standard deviations of the surface roughness. The unpolished specimens showed the following results: G1 = 0.87 ± 0.7 µm, G2 = 0.95 ± 1.1 µm and G3 = 4.2 ± 1.9 µm. The group polished with slurry group yielded the following values: G1 = 0.06 ± 0.02 µm, G2 = 0.06 ± 0.02 µm and G3 = 0.50 ± 0.48 µm, while the cup-polished group showed: G1 = 0.11 ± 0.04 µm, G2 = 0.26 ± 0.19 µm and G3 = 0.2 ± 0.09 µm. No statistically significant differences were found between the types of polishing, but the slurry-polished specimens showed a statistically significant difference between groups G1 and G3 ($p < 0.05$) and G2 and G3 ($p < 0.05$) (Table 1).

Figure 2 shows the mean values and standard deviations of the contact angle measurements. The specimens subjected to standard polishing showed the following values: G1 = 68.3 ± 4.4°, G2 = 69.4 ± 9.3°, and G3 = 62.3 ± 7°, while the cup-polished specimens showed: G1 = 68.3 ± 9°, G2 = 66.3 ± 5.4° and G3 = 60.8 ± 7°. The different polishing techniques yielded no statistically significant difference ($p < 0.46$) in the resins evaluated here. Furthermore, no statistically significant difference ($p < 0.11$) was found between the contact angles of the resins as a function of the polishing techniques (Table 2).

Figure 3 depicts the mean values and standard deviations of the surface microhardness. G1 showed a mean value of 15.45 ± 0.47 HV, G2 of 14.89 ± 0.49 HV, and G3 of 14.38 ± 0.28 HV. The G1 and G3 materials showed statistically significant differences ($p < 0.01$) in surface microhardness (Table 2).

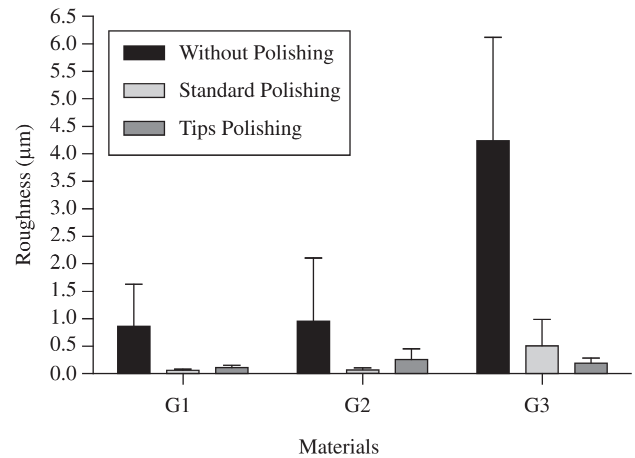

Figure 1. Mean values and standard deviation of surface roughness (µm) of the materials studied.

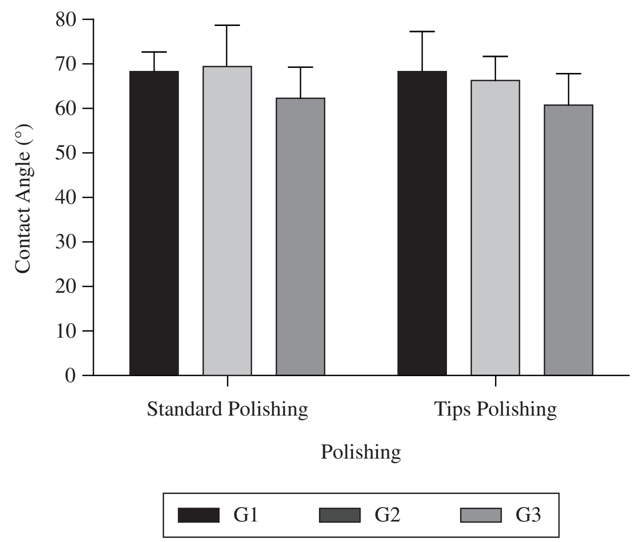

Figure 2. Mean values and standard deviation of contact angle (°) of the materials studied.

Table 1. Mean values and standard deviation of surface roughness of groups (µm), according to the surface treatment.

Group	Surface treatment		
	Without Polishing	Polishing with slurry	Polishing with cup
G1	0.87 ± 0.70	0.06 ± 0.02	0.11 ± 0.04
G2	0.95 ± 1.10	0.06 ± 0.02	0.26 ± 0.19
G3	4.20 ± 1.90	0.50 ± 0.48	0.20 ± 0.09

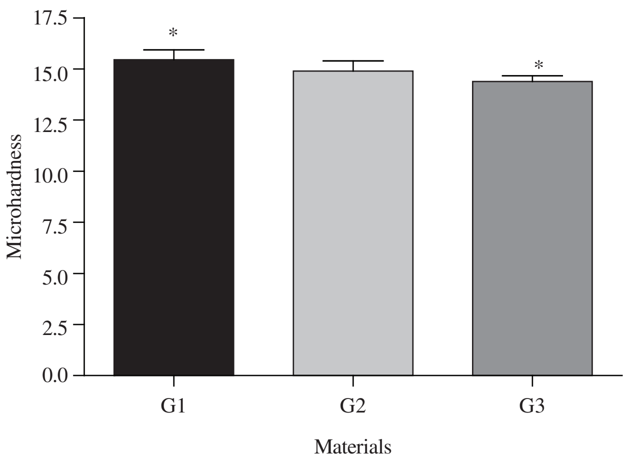

Figure 3. Mean values and standard deviation of Vickers microhardness (MHV) of the materials studied. (*) Significant statistical differences

Table 2. Mean results and standard deviation of Contact Angles (º) and Vickers hardness (VHN) of the materials studied.

Group	Properties		
	Contact angle (º) (polishing with slurry)	Contact angle (º) (polishing with cup)	Vickers hardness (VHN)
G1	68.3 ± 4.4	68.3 ± 9°	15.45 ± 0.47
G2	69.4 ± 9.3	66.3 ± 5.4°	14.89 ± 0.49
G3	62.3 ± 7°	60.8 ± 7°	14.38 ± 0.28

5. Discussion

The surface roughness of dental materials considered clinically ideal by Quirynen et al.[19] and Bollen et al.[23] is close to 0.2 µm or less. All the groups in the present study presented a surface roughness that exceeded this parameter when the specimens were left unpolished, demonstrating that an unpolished provisional fixed prosthesis is unacceptable. After polishing with slurry, the measured roughness of G1 and G2 was lower (0.06 µm), although that of G3 was higher than the ideal (0.50 µm). According to Berger et al.[7], self-curing acrylic resins should be polished using the standard polishing technique (pumice and whiting slurry). However, our results indicate that the G3 material is clinically unsuitable if subjected only to the standard polishing procedure.

In the cup-polished group, only G1 presented an ideal surface (0.11 µm). The slight variation of 0.2 µm was negligible, since the cytotoxicity of monomers may have an antibacterial effect on microbiota on the surface of the material[23]. According to Campanha et al.[24], residual monomers may have a cytotoxic effect on a number of cells. Hence, further studies about the attachment of bacteria on such surfaces are needed.

In our study, however, the superficial roughness of polished surfaces decreased significantly in relation to that of the unpolished ones. This greater smoothness should help reduce the attachment of bacteria and maintain periodontal integrity, regardless of the polishing technique employed. Furthermore, to improve surface quality, Mantikos et al.[25] propose the application of a layer of glaze, claiming that in provisional restorations, this procedure is indicated to reduce bacterial attachment. However, Sesma et al.[26] demonstrated that glaze applied on definitive surfaces did not prevent bacterial attachment, although it aided its removal.

Several authors[27,28,29,30] have stated the importance of choosing adequate parameters for surface roughness measurements. Because the Ra parameter is limited to horizontal measurements[27,28,29], different surfaces could present the same roughness values, thus rendering the results questionable. Nevertheless, since this parameter is a routine method[1,14,15,16,17,30], it was adopted here to facilitate comparisons with previous studies.

The contact angle created between the water and the acrylic resin should be, on average, 75°[31]. This is an important property, for it indicates the saliva's ability to flow over the surface of a material. In this study, after the application of both polishing techniques, all the groups presented mean contact angles lower than but very close to 75°. Since no statistically significant differences were found between the contact angles resulting from the two polishing techniques, or between the resin brands, this value was considered acceptable for the good superficial energy presented by the three acrylic resin brands.

The Vickers microhardness test is based on the ability of the surface of any material to resist the penetration of a specific tip with a given load for a specific time. In our study, the surface hardness of the G1 and G3 materials showed differences. The mean microhardness values (15.45 HV; 14.89 HV and 14.38 HV) of the materials evaluated here were lower than those assessed by Pavarina et al.[11] (17.0 HV and 16.6 HV) in artificial teeth used in complete prostheses, and lower than those reported by Campanha et al.[24], even when the teeth were subjected to sterilization cycles, which could reduce their surface hardness. Although artificial teeth and the materials used in provisional prostheses are made of acrylic resins, the greater hardness of artificial teeth is probably attributable to the fabrication process, since the conditions for handling and polymerizing these materials in an industrial environment enhances their physical and mechanical properties.

6. Conclusions

Within the limitations of this in vitro study, and based on the present methodology, the following conclusions were drawn:

1. The two polishing techniques yielded similar surface roughness results. However, in the group polished with slurry (standard polishing), G3 displayed greater surface roughness than G1 and G2;
2. The polishing methods did not affect the contact angle of the materials tested here;
3. No differences were observed in the contact angles of the various materials subjected to the two polishing techniques; and
4. G1 showed higher mean Vickers hardness values than G3.

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