Surface roughness of acrylic resins processed by microwave energy and polished by mechanical and chemical process

Abstract
The aim of this study was to evaluate the influence of polymerization methods (microwave energy - MW, and water bath - WB) and polishing techniques (chemical - C and mechanical - M) on the surface roughness of one heat-polymerized acrylic resin (Vipi-Cril). Forty acrylic resin disk-shaped samples were made according to ADA specification nº 12. Half of samples were processed by microwave energy (500W for 3 minutes), and the other half by water bath (74±1 °C for 9 hours). After deflasking, the samples were trimmed with a sequence of abrasive aluminum oxide sandpapers of different grades (180, 220 and 400) and divided in 4 groups according to polymerization methods and polishing techniques: G1: MW+CP, G2: MW+MP, G3: WB+CP and G4: WB+MP. Surface roughness values were measured using a Surfcorder SE 1700 rugosimeter (Kosaka Laboratory Ltd, Kosaka, Japan). Mann-Whitney test (p=.05) indicated significant differences between polishing methods processed by microwave energy (p= .0018), and between polishing methods processing by water bath (p= .0002). Samples processed by both methods (water bath or microwave energy) showed smoother surfaces when polished by mechanical polishing method, and polymerization methods did not influence in surface roughness.

Key Words:
aCRYllic resin, polishing, surface roughness, microwave processing
**Introduction**

Surface roughness is an important property of acrylic resin since denture bases are in contact with buccal tissues, and a rough surface may affect tissues health due to microorganism accumulation\(^1\). Smooth and highly polished denture surface are of utmost importance for patient comfort and denture longevity, and it is desired for reducing microorganism’s retention\(^2\). It can improve good aesthetical results, oral hygiene and low plaque retention, preventing oral diseases\(^3\). Finishing and polishing procedures are essential steps in obtaining a smooth acrylic surface\(^4\). Two polishing methods are frequently used in the denture finishing: mechanical and chemical process. Mechanical polishing uses abrasive drills and aluminum oxide sandpapers in decreasing granulations, pumice slurry with felt cone and chalk powder with a soft brush at a bench vise\(^4,5\). As the mechanical technique, chemical polishing is biocompatible, and was developed to eliminate the abrasive polishing sequence, and to save time. In this case, the finished prosthesis is immersed in monomer heated at 100.3\(^\circ\)C\(^6\).

Nishii\(^7\) introduced polymerization of acrylic resin by microwave energy in 1968. This technique can be considered practicable because it is a clean and practical method and avoids wasting time in addition. Possible homogeneous heating of gypsum and acrylic resin mass during polymerization is also an advantage because it may reduce acrylic tensions and distortions\(^7,8\). However, temperatures over 90\(^\circ\)C could promote tension and distortions of acrylic resin, increasing the possibility of superficial roughness\(^8\). Careful surface texture measurement can facilitate understanding of how the acrylic will stain or wear in vivo\(^9\).

Response to oral hygiene measure such as tooth brushing is an important factor in clinical performance of the material. Studies related to methods of polishing acrylic resin and microwave energy polymerization are necessary in order to assure the safety and reliability of their use.

The aim of this study was to evaluate the influence of polymerization methods (microwave energy - MW and water bath - WB) and polishing techniques (chemical - C and mechanical - M) on the surface roughness of one heat-polymerized acrylic resin. The experiment involved 40 acrylic resin samples (50±1 mm in diameter and 0.5±0.05 mm in thickness). The samples were prepared and divided into 4 groups (10 samples each) according to polymerization methods and polishing procedures (Table 1).

**Material and Methods**

Steel disk-shaped patterns in accordance to Specification nº 12 of American Dental Association (A.D.A.)\(^11\), were used to prepare forty heat polymerized acrylic resin samples (50±1 mm in diameter and 0.5±0.05 mm in thickness). The patterns were included in metallic flasks (DCL\(®\) n.5.5, Bethil Ind. Ltd, Campinas, São Paulo, Brazil) and polyvinyl chloride (PVC) flasks (Onda-Cryl\(®\), Artigos Odontológicos Clássico Ltd, São Paulo, São Paulo, Brazil), to make the gypsum molds for constructing resin samples (Figure 1). Acrylic resin samples were prepared and divided in 4 groups (10 samples each) according to polymerization methods and polishing procedures (Table 1).

**Heat-polymerized acrylic resin developed to microwave and heat water polymerization (Vipi Cril\(®\), Dental Vipi Artigos Odontológicos Ltd, Pirassununga, São Paulo, Brazil) was prepared according to manufacturer’s instructions, and included in the gypsum molds\(^12\-\(^13\).**

Microwave energy (MW) was used in processing half samples, and the other half was processed by water bath (WB), according the following methods: metallic flask, by water bath for 9 hours at 74 ± 1°C (Righetto & Salin Comp, Campinas, São Paulo, Brazil); and PVC flasks, by microwave energy (Panasonic MN 7806 BH, 1380W, Amazon, Brazil), at 500W for 3 minutes. After polymerization cycles, the flasks were allowed to bench cool for 3 hours\(^8\).

Machine grinding APL 04 (Arotec, São Paulo, Brazil) procedures were conducted employing abrasive papers in successive grits of 320, 400 and 600. During finishing procedures, the samples were held by a steal cylindrical support to standardize pressure and thickness\(^12,13\). Steel disk-shaped patterns and digital caliper (Starrett\(®\), Microtec Ltd, São Paulo, Brazil) were used to hold and to control thickness specimens during all finishing procedures.

Ten WB samples and ten MW samples were mechanically polished in a bench vise with soft brush and pumice slurry,
flannel wheel and chalk powder. In order to standardize pressure applied on sample surface during mechanical polishing, the stainless steel support was used (Figure 2). Ten WB samples and ten MW samples were chemically polished in a chemical polisher PQ 9000 (Termotron®, Piracicaba, São Paulo, Brazil) with monomer heated at approximately 75± 1 °C (VIPI®, Dental Vipi Artigos Odontológicos Ltd, Pirassununga, São Paulo, Brazil). The samples were immersed in the fluid for 10 seconds (Figure 3), subsequently dried for 15 seconds, and washed in current water for 1 minute to remove excess monomer.

Surface roughness was measured using a Surfcorder SE 1700 roughness meter (Kosaka Laboratory Ltd, Kosaka, Japan), by a second calibrated researcher characterizing a blind study. Readings were taken at six different positions (A to F) on each sample established on the superior surface of the stainless steel cylindrical support (Figure 4). Were used the following standardizations: cut-off 0.25mm, 1.25mm of samples lengths; 0.5mm of pre and post-reading; mean of 0.5mm/s to reading speed; 80μm of action sphere; Gaus filter; and sequential reading way. A needle passing five consecutive times across lengths obtained the readings. Ninety roughness values were obtained for each sample, and averages were calculated to each sample.

Results

The data of surface roughness (μm) for the polishing techniques to each polymerization methods are presented in Table 2. Mann-Whitney test for two independents specimens (p= 0.05) indicated significant differences between chemical and mechanical samples, processed by microwave energy (G1 and G2) (p=0.0018) and processed by water bath (G3 and G4) (p=0.0002). Groups submitted to mechanical polishing processed by microwave (G2) showed the lowest surface roughness values (median=0.094). There was no significant difference between microwave or water bath samples polished by chemical (p=0.13) or mechanical process (p=1).

Discussion

Surface roughness of acrylic resin used in dentures improves good aesthetical results and may influences microorganism’s retention. Rough surfaces of bridges, implant abutments and denture bases accumulate and retain more dental plaque than smooth surfaces. It affects the oral health of edentulous tissues in direct contact with denture, because bacteria joined in irregular surfaces can survive for a long periods of time. The rough surface protects bacterial sites from natural removal forces and even those of oral hygiene methods. The surface roughness threshold for acrylic resins is 0.2 mm; under which no significant decrease in bacterial colonization would occur. In the present study, when mechanical polishing was applied, roughness values were lower than values found in the literature. This method uses abrasives of finest grit sizes improving surface smoothness, because it promotes surface abrasion with material removal, generating traces or notches with progressively lower dimensions as finer grits are utilized.
On the other hand, chemical polishing performs differently. Table 2 shows higher values than 0.2 mm to chemical polishing groups. The same results were presented by Rahal et al.\textsuperscript{10}. It occurred probably because methyl methacrylate molecules present in the polishing fluid penetrate superficial polymeric chains of the acrylic resin, breaking their join secondary bonds, promoting a final plasticizing effect of the acrylic resin surface. According to those authors\textsuperscript{10}, it has no effects on the irregularities in finishing procedures. It could suggest if CP procedures had been applied after abrasive granulation finer than 600, surface would remain smooth, and thus would promote lower surface roughness than those obtained in the present study. We agree with the authors who say that other researches are necessary to confirm this hypothesis. There were no significant differences among microwave irradiation and water bath processing groups (p = .0881) when the same polishing method was applied, as showed in Table 2. Apparently the heating method doesn’t interfere in polymeric chain of acrylic used in the present work when used in association with mechanical polishing. It doesn’t create any modifying to plasticizing surface acrylic resin too. As Rahal et al.\textsuperscript{10}, the present experiment finds difference between mechanical and chemical polishing samples processed by microwave energy. However the values obtained by those authors were insufficient for retaining bacteria. In the present study was observed the combination of microwave energy processing and chemical polishing produced roughness surface higher than those of bacteria measurement. Probably this different data occurred because different methodological procedures and number of samples were used in both experiments. Its suggest that the cross-linking agents concentration of Onda Cryl is different from the other acrylic resins used in those experiment, and according to the proposed by the authors, concentration level of cross-linking agent could significantly affect the influence of these agent on properties of resin. While microwave polymerization technique can be considered practicable because it is a clean and practical method, and avoids wasting time in addition\textsuperscript{7,8}, its association with chemical polishing could reduce timework for final denture construction. However, according to the obtained results, bacteria could be protected against hygienic brushing procedures\textsuperscript{2}, and the damage observed on resin surface roughness contraindicates this association. We consider that is extremely important to consider the roughness values attained during the course of denture preservation. Since surface roughness of chemical polishing are dependent on acrylic resin type and processing method, and it doesn’t occurs when resin is polished by mechanical methods and processed by microwave energy, we suggest that the association of mechanical polishing and microwave processing could be used clinically. However is considered that additional studies are necessary to confirm the log-term behaviors of surface roughness, polymerization and polishing techniques, and other properties of resins. In conclusion, based on the results obtained, we can conclude that: 1) The polymerization process (microwave or water bath) didn’t influence surface roughness values of heat-polymerized acrylic resin; 2) The polishing method (mechanical or chemical) influence surface roughness values of heat-polymerized acrylic resin; 3) Mechanical polishing promoted smoother surfaces than chemical polishing.

### References

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