Original Article

Surface Roughness of Auto Polymerized Acrylic Resin According to Different Manipulation and Polishing Methods

An In Situ Evaluation

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ABSTRACT

Objective: To test the hypothesis that no differences exists in the in situ level of surface roughness of an auto polymerized acrylic resin irrespective of the method of manipulation and polishing.
Materials and Methods: Forty volunteers received the test specimens. Surface roughness was evaluated using a rugosimeter. Samples of auto polymerized acrylic resin were submitted to two methods of manipulation—mass and addition—as well as to two types of polishing—mechanical and chemical. Four test groups were designated according to manipulation and polishing techniques: mass-mechanical, mass-chemical, addition-mechanical, and addition-chemical. Five measures of surface roughness were taken from each sample and average surface roughness (Ra) was determined before and 20 days after the samples were worn by the volunteers. The data obtained were analyzed by the Student's *t*-test for paired samples as well as by analysis of variance.
Results: Significant differences in Ra were found between mechanical and chemical polishing. Surface roughness was not influenced by manipulation techniques. Mechanical polishing presented the lowest values of Ra. There was a significant increase in surface roughness after volunteers wore the specimens for 20 days.
Conclusions: The hypothesis is rejected. There were differences on the surface roughness according to the different methods of manipulation and polishing used, but high values of surface roughness were found for all groups. Mechanical polishing showed the lowest values of surface roughness and thus should be preferred.

KEY WORDS: Acrylic resin; Orthodontics; Polishing; Removable appliances

INTRODUCTION

Polymethyl methacrylate (PMMA) resins are high molecular weight polymers that polymerize in an addition reaction. Although the curing process can be initiated by heat or light, a chemical initiator is used more often.[1]

In orthodontics, chemically activated PMMA resins are used to build up removable or auxiliary fixed appliances and for retainers. There are different techniques for manipulating and polishing this material.[2] For manipulation, two techniques are described: the addition (or salt and pepper) technique,[2,3] in which the polymer is saturated by its monomer and which is widely used in orthodontics; and the mass technique, which is also a cold-cure technique, in which powder and liquid are mixed together,[2] as is commonly done in prosthodontics.

After polymerization, PMMA appliances are ground and polished.[1] Polishing can be carried out through mechanical devices[2,4] (mechanical polishing) or through chemical products (chemical polishing), which consists of immersing the acrylic appliance in heated chemical polishing liquids.[5] Chemical polishing has the advantage of being less time consuming.[5]

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Table 1. Experimental Groups Division According to Manipulation and Polishing Techniques

Manipulation	Polishing	Group
Mass	Mechanical	Mass-mechanical
	Chemical	Mass-chemical
Addition	Mechanical	Addition-mechanical
	Chemical	Addition-chemical

The manipulation and polishing techniques used may affect the surface roughness of orthodontic appliances and as a result may influence the patient's comfort and the hygiene of the acrylic appliance. The aim of this study was to test the influence, *in situ*, of manipulation and polishing techniques on the surface roughness of an auto polymerized acrylic resin.

MATERIALS AND METHODS

A methyl methacrylate (MMA) auto polymerized acrylic resin (JET, Clássico, São Paulo, Brazil) was analyzed for this in situ study. Forty volunteers took part on the investigation, signing an agreement form. This investigation was also approved by the ethical committee of the University.

An impression was taken of the maxillary arch of each volunteer. Cast models were obtained for each subject, for the construction of an auto polymerized acrylic resin appliance with no clasps. The samples were attached to this appliance with a double-faced adhesive tape, which kept them in contact with the saliva. During the appliance's curing process, a metallic matrix (16 mm $\times$ 13 mm $\times$ 3 mm) was placed over the resin, creating a depression on the appliance, so that the samples could be placed and avoid any harm to the volunteers.

Four experimental groups were established (Table 1). Each one had 10 volunteers. For each volunteer a sample was made to analyze surface roughness at the beginning of the testing as well as 20 days after contact with the saliva.

To obtain the samples, a metallic matrix (5 mm $\times$ 5 mm $\times$ 2 mm) was impressed with silicon. This impression was filled with acrylic resin. Powder was weighed (AG204, Metler Toledo, Switzerland) and liquid was measured with a microsyringe (Lab Mate, PZ HTL S.A., Warsaw, Poland), following the manufacturer's instructions. For manipulating mass, polymer and monomer were readily mixed together, and the resin was poured into the mold. For the addition technique, powder and liquid were gradually poured into each impression. After 20 minutes, the samples were ground with a tungsten bur and abrasive paper (#400 and #600) and polishing was begun.

For mechanical polishing, a black brush and felt wheel with a pumice slurry were used. After that, a soft wheel was applied with chalk powder. Each instrument was applied 10 times for two seconds, and instruments were discarded after polishing 15 samples. In the chemical polishing groups, samples were drowned in the chemical polisher (PQ-9000, Termotron, São Paulo, Brazil), containing 20 mL of chemical polishing liquid (Poli Quim, Clássico, São Paulo, Brazil) at 70°C for eight seconds. This liquid is basically composed of MMA, but some stabilizers are also added to the formula. The samples were left to bench dry until visible excessive monomer could evaporate, which took about 30 minutes.

Table 2. Comparison of Initial and 20-day Average Surface Roughness for Each Evaluated Group

Comparison	n	Mean (μm)	Standard Deviation (μm)	*P*
Mass-mechanical				
Initial	10	1.33	0.49	.05*
20 day	10	1.59	0.64	
Mass-chemical				
Initial	10	2.92	0.72	.51
20 day	10	2.99	0.70	
Addition-mechanical				
Initial	10	1.20	0.38	.01*
20 day	10	1.63	0.50	
Addition-chemical				
Initial	10	3.06	0.89	.03*
20 day	10	3.42	0.90	

* Statistical difference.

A rugosimeter (Mitutoyo Surftest SJ-201, Kanagawa, Japan) was used to measure the surface roughness. Readings were done in the acrylic sample, which was settled over a wax lamina, immediately after polishing and 20 days after the samples were in contact with saliva. At both times, the same face of the sample was analyzed. A dental clamp was used to remove the sample from the appliance and settle it over the wax lamina. Five roughness measurements (μm) were performed on each sample using the rugosimeter with a cutoff value of 0.25 mm and an average surface roughness (Ra) of the readings was obtained. The equipment was previously calibrated according to the manufacturer user's manual.

For statistical analysis, the software SPSS version 10.0 (Chicago, IL) was used. Student's *t*-test (paired and independent) and analysis of variance (ANOVA) associated to the Tukey test were used for the evaluations.

RESULTS

The paired Student's *t*-test (Table 2) showed a statistical difference between the initial and 20 days' val-

Table 3. Comparison of Average Surface Roughness between Groups in Both Analyzed Periods

Comparison	n	Mean** (μm)	Standard Deviation (μm)	*P*
Initial				
Mass-mechanical	10	1.33[a]	0.49	
Mass-chemical	10	2.92[b]	0.72	.01*
Adittion-mechanical	10	1.20[a]	0.38	
Addition-chemical	10	3.06[b]	0.89	
20 day				
Mass-mechanical	10	1.59[a]	0.64	
Mass-chemical	10	2.99[b]	0.70	.01*
Addition-mechanical	10	1.63[a]	0.50	
Addition-chemical	10	3.42[b]	0.90	

* Statistical difference.

** Means followed by the same letter are not statistically different.

Table 4. Comparison of Average Surface Roughness According to Manipulation Technique at Initial and 20-day Periods

Comparison	n	Mean (μm)	Standard Deviation (μm)	*P*
Initial				
Mass-mechanical	10	1.33	0.49	.52
Addition-mechanical	10	1.20	0.38	
20 day				
Mass-mechanical	10	1.59	0.64	.88
Addition-mechanical	10	1.63	0.50	
Initial				
Mass-chemical	10	2.92	0.72	.71
Addition-chemical	10	3.06	0.89	
20 day				
Mass-chemical	10	2.99	0.70	.25
Addition-chemical	10	3.42	0.90	

ues for all groups, except for mass-chemical. For significant comparisons, in 20 days there was an increase of the values. ANOVA (Table 3) showed statistical differences between the groups at both analyzed times. The mass-chemical and addition-chemical groups showed higher Ra values, which did not differ from each other, while the mass-mechanical and addition-mechanical groups showed the lowest average values, which also did not differ from each other.

In Table 4, using independent Student's *t*-test, the variable "polishing" was isolated to evaluate manipulation technique alone. For these comparisons, there were no significant statistical differences. On the other hand, Table 5, also using independent Student's *t*-test, shows a comparison between polishing techniques, while the variable "manipulation" was isolated. In all the comparisons there were statistical significant differences between mechanical and chemical polishing.

Table 5. Comparison of Average Surface Roughness According to Polishing Techniques at Initial and 20-day Periods

Comparison	n	Mean (μm)	Standard Deviation (μm)	*P*
Initial				
Mass-mechanical	10	1.33	0.49	.01*
Mass-chemical	10	2.92	0.72	
20 day				
Mass-mechanical	10	1.59	0.64	.01*
Mass-chemical	10	2.99	0.70	
Initial				
Addition-mechanical	10	1.20	0.38	.01*
Addition-chemical	10	3.06	0.89	
20 day				
Addition-mechanical	10	1.63	0.50	.01*
Addition-chemical	10	3.42	0.90	

* Statistical difference.

DISCUSSION

It is well known that smooth surfaces are important for dental materials as there is positive association between surface roughness and microorganism accumulation.[6,7] In this study, surface roughness was tested to observe if the manipulation and polishing techniques used could affect this property. Polishing techniques indeed influenced the Ra; mechanical polishing was superior to chemical polishing in this aspect (Table 2), as only the first one achieved surface roughness under 2.0 μm, which is the value previously established as a threshold for surface roughness in these cases.[7] This is in accordance with Rahal et al,[8] who also found that the chemical polishing generated rougher surfaces than mechanical polishing.

Zissis et al[9] did not polish the tested surfaces and found surface roughness between 3.4 and 7.6 μm, higher than the values found in the current study. This probably indicates that any kind of polishing technique, either mechanical or chemical, is important to reduce roughness.

The time consumed for polishing was evaluated by Berger et al,[10] who showed that, although there are many chair-side kits for polishing that would take less time, conventional polishing with a lathe is superior. With respect to the time, because chemical polishing only involves the immersion of the acrylic appliance in chemical polishing liquids for approximately eight seconds, it is the fastest.

Although chemical polishing does not seem to be time consuming,[5,11] other properties are influenced by this practice. Nunes de Mello et al[11] showed that chemical polishing led to excessive levels of residual monomer. This is not desired considering the biocompatibility of this material.

Braun et al[12] studied some properties of the chemically polished acrylic resin and evaluated surface roughness under the scanning electron microscope (SEM) analysis, whereas in the current study, surface roughness was evaluated using a rugosimeter. It would be interesting to have a study confronting Ra obtained with devices as rugosimeters and the qualitative analysis propitiated by the SEM.

In the current study, all grinding and polishing were done using a portable micromotor. This certainly contributed to the high Ra, as it has already been shown[10,13] that polishing on a lathe is better than chairside polishing. However, it must be considered that most dentists do not have a lathe in their office. Also, many professionals use a portable micromotor, especially when repairs are done on prosthodontic and orthodontic appliances. This study tried, in a way, to replicate the reality in a dental office.

There was a statistical difference for surface roughness between the initial and 20-day values. After this period, there was an increase in surface roughness, probably because of accumulation of biofilm, cells, and other salivary components. It is possible that when the surfaces are initially smoother, it takes longer to accumulate plaque and surface roughness values may remain low for a longer time.

Besides mechanical and chemical polishing, some ultraviolet light–activated sealants can be used for polishing. Sofou et al[14] verified that surface roughness obtained with this material was similar to that found in mechanical polishing. These materials, as well as chemical polishing, are not time consuming to use. Valittu[15] evaluated the effect of different surface treatments on residual monomer and found that these sealants led to reduced levels of residual monomer, probably because of an increase in temperature during the curing cycle. These sealants were not investigated here, but they seem to be an advantageous alternative, as they can create benefits not only for surface roughness but also for residual monomer.

A smoother surface is more comfortable, so it would be desirable to always minimize surface roughness. Also, to avoid caries and periodontal disease, its always important to reduce the possibility of plaque retention. Despite the limitations of this study, it is possible to say that mechanical polishing was superior to chemical polishing and should be recommended, considering the mechanical and biological disadvantages of chemical polishing.[11,12]

CONCLUSIONS

- There was an increase in surface roughness after 20 days of use of the acrylic samples by volunteers.
- Mechanical polishing led to the lowest values of surface roughness. Polishing techniques influenced surface roughness more than the manipulation techniques. As mechanical polishing presented a better performance, it should be recommended.

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