Linear dimensional change in acrylic resin disinfected by microwave energy

Alteração dimensional linear de resinas acrilicas desinfetadas por energia de microondas

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Abstract

The purpose of this study was to characterize the linear dimensional change in specimens made in aluminum rectangular dies (65.0x12.0x3.5mm), with 4 reference demarcations, using the Clássico, Onda-Cryl and QC-20 brands of acrylic resin. Wax patterns with 67.0x15.0x5.0mm were embedded in metallic or plastic flasks with stone gypsum, according to the conventional technique. After stone gypsum setting, the wax molds were removed and the aluminum dies impressed in the stone gypsum mold with silicone material. The powder/liquid proportion and acrylic resin were manipulated according to manufacturer's instructions. The metallic flask pressure was achieved using the RS tension method. After polymerization in water at 74°C for 9 hours, ebullition water for 20 minutes or microwave energy (900 W) for 10 minutes, the specimens were cooled at room temperature and then removed from the flasks and submitted to conventional finishing. The distances between the A-B, C-D, A-C, and B-D reference points were measured before and after disinfection by microwave energy (650W for 3 minutes). The linear dimensional evaluation of the distances was performed by the same operator with an Olympus optical comparator microscope, with an accuracy of 0.0005mm. Obtained data were submitted to ANOVA and Tukey's test (α=.05%). The disinfection by microwave energy did not alter the original linear dimensions of the specimens.

Uniterms

Dimensional changes; acrylic resins; microwave; disinfection; materials testing; dental desinfectants

Introduction

The shrinkage that occurs when monomers are converted into polymers during the polymerization reaction, as well as the stress released during the flask cooling, are the main factors responsible for the dimensional changes that occur in acrylic resin[2]. Due to the decrease in the molecular weight of the resulting polymer chain[17], the changes introduced in the technical processing of the acrylic resin are not able to alter the dimensional behavior pattern of the material[8].

In contrast, the extent of the dimensional change of the acrylic resin is influenced by the polymerization method, due to the different coefficients of thermal expansion of the stone and resin[4] and by the base thickness, with different positions inside the flask;[15] factors which affect the retention and stability of the denture when in clinical use[10].

The resultant distortion from the cooling and removal of the base from the stone cast also leads to the release of stress induced during the procedure.[11] Consequently, the association between polymerization shrinkage and stress release decreases the adaptation level of the base on the support tissues, reducing the denture stability[1,18].

Research continues to show that the adaptation of the denture to the stone cast remains unsatisfactory, due to the influence of the base thickness[6] and of the commercial brands of acrylic resins.[6] The polymerization shrinkage is not uniform, occurring to a greater extent in the posterior palatal region,[5] while the distortion by cooling or by the base removal from the stone cast results in the release of the internal stresses incurred during the denture procedure.[2]

Some techniques of processing have been suggested for replacement of the traditional long cycle of hot water,[13] such as the use of microwave energy,[12,16] which may reduce some variables that may affect base stability. Microwave energy has also been suggested for the sterilization of dental instruments and dentures affected with a *Stafilococos aureus, Stafilococos epidermis, Klebsiella pneumonia* and *Cândida albicans* blend[14].

Due to factors inherent to the physical properties of the acrylic resin and the processing techniques, the ability of microwave energy to cause linear dimensional change in acrylic resins was characterized. The negative hypothesis proposed was that disinfection by microwave energy would alter the dimensions of specimens.

The purpose of this study was to verify the linear dimensional change in specimens made with Clássico (cycle long), QC-20 (short cycle) or Onda-Cryl (microwave energy) following microwave disinfection.

Material and Method

The materials used in the making of the specimens are shown in Picture 1.

Picture 1 – Commercial name, basic composition and acrylic resin manufacturer

Commercial name	Basic composition*	Manufacturer
Clássico	Powder: poly-methyl metacrylate Liquid: methyl metacrylate	Clássico
QC-20	Powder: co-polymer of methyl/n butyl metacrylate, peroxide of benzoile and mineral pigments Liquid: methyl metacrylate, ethyleneglycol, dimetacrylate, hydroquinone, tertinolene, and n,n-dimetyl p-toluidine.	Dentsply/De Trey
Onda-Cryl	Powder: co-polymer of MMA and EADPB, and peroxide of benzoile. Liquid: monomer of MMA, topanol, etylene-glycol-dimetacrylate	Clássico

* Manufacturers´ information

Three aluminum rectangular dies with dimensions of 65.0x12.0x3.5mm were made with 4 equidistant reference points; two at each of the ends (Figure 1). Wax rectangular molds with dimensions of 67.0x15.0x5.0mm were embedded in stone gypsum in metallic or plastic flasks, according to conventional gypsum inclusion.

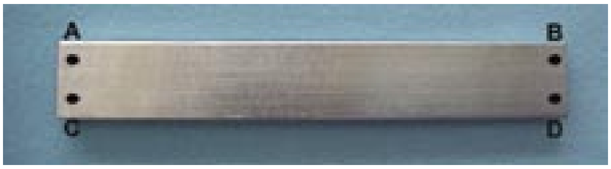

FIGURE 1 – Metallic die for specimen making

The wax molds were invested in Herodent dental stone (Vigodent, Rio de Janeiro) in the lower part of the metallic (Safrany, São Paulo) or plastic (GC, São Paulo) flasks, using a ratio of 30mL water to 100g powder, according to the manufacturer's instructions. Petroleum jelly was used as a separating medium between the stone in the lower part of the flask and the dental stone used in the upper portion. The flasks were pressed in a bench press for 1 hour.

The flasks were opened and the wax molds removed. The stone molds in the flasks were filled with Perfil heavy silicone (Vigodent) and the aluminum metallic dies were molded in the silicone. After the silicone polymerization, the aluminum metallic dies were removed and the impression accuracy of the referential points verified in the silicone molds.

Ten specimens were made for each acrylic resin type and were proportioned and manipulated, according to manufacturer's instructions, for the following protocols in the experimental groups: 1- Clássico acrylic resin packing, polymerization in water at 74ºC for 9 hours in an automatic thermopolymerizer (Termotron, Piracicaba) and deflasking after flask cooling in the polymerization water. 2- Onda-Cryl acrylic resin packing, polymerization by microwave energy in a domestic oven (Continental, São Paulo) with 900 W in potency: 3 minutes with 40% of the potency, 4 minutes with 0% of the potency, and 3 minutes with 90% of the potency, and deflasking after bench flask cooling. 3- QC-20 acrylic resin packing, polymerization in ebullition water for 20 minutes under steam tension and deflasking after bench flask cooling.

Clássico and Onda-Cryl acrylic resins (Clássico, São Paulo) were used with a monomer:polymer ratio of 1:3 by volume, corresponding to 37.5g powder to 15mL liquid. A ratio of 23g powder to 10mL liquid was used for QC-20 resin (Dentsply/DeTray). The prepared dough was packed, in the dough-like stage, in an H 2000 hydraulic press (Linea, São Paulo), with a load of 850 kgf. After the flask was opened, the plastic sheet was removed and the acrylic resin excess trimmed. In the metallic flask procedure, the final closure was performed with the flask set between the 2 plaques of the RS system method,[5] under a load of 1 250 kgf for 5 minutes. The final closure of the plastic flasks was under a load of 800 kgf for 5 minutes.

After polymerization, the specimens were removed from the metallic or plastic flasks by the routine procedure. Finishing was carried out using stones for acrylic resin abrasion and sandpaper with decreasing abrasiveness. Pumice was used with white and black brushes and felt tips for polishing in a bench lathe. After final polishing with a flannel wheel and universal paste (Koda, São Paulo), the specimens showed dimensions of 65.0x10.0x3.3mm according to ISO[9]. After polishing, the specimens were stored in distilled water at 37^0C for 24 hours.

Five specimens from each group were each immersed in 150mL of distilled water in a glass container and disinfected in a domestic microwave oven (Continental) calibrated to 650W, for 3 minutes[3].

The distances between the A-B, C-D, A-C and B-D referential points were measured before and after the microwave energy disinfection. Linear dimensional evaluation of the distances was performed by the same operator using an Olympus optical comparator microscope (Japan), with an accuracy of 0.0005mm.

Data obtained from the measurements, before and after the disinfection, were submitted to ANOVA and Tukey's test with 5% of significance and 3 factors were analyzed: acrylic resin type, treatment and the interaction between these factors.

Results

Table 1 shows the mean values of the AB, CD, AC and BD distances in the specimens made with the Clássico, Onda-Cryl and QC-20 acrylic resins before and after microwave disinfection. There were no statistically significant differences when the linear dimensional change was compared for the conditions of before and after microwave disinfection. Comparisons between acrylic resins with respect to each treatment condition also did not show any statistically significant difference between the distances.

Table 1 – Mean values for the AB, CD, AC and BD distances (mm) for the Clássico, QC-20 and Onda-Cryl acrylic resins before and after microwave disinfection

		Clássico	QC-20	Onda-Cryl
AB	Before	59.34 ± 0.48 aA	58.93 ± 0.55 aA	59.59 ± 0.70 aA
	After	59.28 ± 0.48 aA	58.92 ± 0.43 aA	59.45 ± 0.71 aA
CD	Before	59.42 ± 0.27 aA	58.89 ± 0.71 aA	59.34 ± 0.61 aA
	After	59.57 ± 0.25 aA	59.29 ± 1.00 aA	59.32 ± 0.68 aA
AC	Before	5.10 ± 0.25 aA	4.70 ± 0.28 aA	4.73 ± 0.35 aA
	After	5.14 ± 0.28 aA	4.75 ± 0.27 aA	4.73 ± 0.37 aA
BD	Before	4.94 ± 0.23 aA	4.86 ± 0.22 aA	5.04 ± 0.46 aA
	After	4.96 ± 0.25 aA	4.90 ± 0.22 aA	5.01± 0.38 aA

Means followed by identical small letters for each distance in the column and capital letters in each row do not differ statistically using the Tukey's test analysis (5%).

Discussion

Acrylic resin polymerization by microwave energy[7,12,16] has been suggested as an alternative technique to the traditional procedure of a long cycle in a hot water bath[13] in order to decrease variables that may influence denture base stability.

Microwave energy has been shown to efficiently disinfect dentures affected by a *Stafilococos aureus, Stafilococos epidermis, Klebsiella pneumonia* and *Cândida* albicans blend[14] and a resilient soft liner contaminated by *Cândida albicans* or *Stafilococos aureus.* Since this disinfection technique is considered as quick and efficient it certainly may be advantageous for some patients;[3] furthermore, microwave energy also has been suggested for use in dental instrumental sterilization.[14]

This study tested the hypothesis that microwave disinfection would have a negative effect on the dimensional stability of the thermopolymerized acrylic resins, as evaluated by means of pre-established measurements in rectangular specimens.

Values of the AB, CD, AC and BD distances (mm) showed that there were no statistically significant differences when the linear dimensional changes of the Clássico, QC-20 and Onda-Cryl acrylic resins were compared before and after microwave disinfection. When each acrylic resin was separately compared in relation to each distance, there were no statistically significant differences between the before and after linear values in all distances studied (Table 1).

This fact signifies that the period of 3 minutes with a potency of 650W was not sufficient to promote linear dimensional change between the distances. Probably, the induced stress in the acrylic resin procedure was not released under microwave energy or the strength of the released stress was not enough to alter the distances, due to the geometrical configuration of the specimens.

In contrast, the literature shows that dimensional changes in dentures occurred with an exposure of 10 minutes of microwave energy with high potency; however, only 6 minutes at a lower potency is sufficient to promote a disinfection whilst maintaining the dimensional stability.[19] In this situation, the heat promoted by the 10 minute exposure promoted distortion of the denture base, mainly in the posterior portion of the palate, which is more vulnerable to dimensional change than the anterior region.[5] When the exposure time was decreased in this study, the heat generated was not enough to release the induced stress and to promote dimensional change in the acrylic resin specimens.

Similarly to the polymerization by the hot water bath technique, the polymerization by microwave energy is also influenced by the inclusion in gypsum volume, by the amount of water included in the gypsum, by the monomer/polymer ratio, by the thermal conductibility of the flask, and by the translucency of the flask material.[7] Probably, due to these factors, the polymerization level of the acrylic resins with or without disinfection was similar, producing linear dimensional change for all distances with no statistically significant differences (Table 1). Consequently, the microwave energy disinfection of the specimens did not have any effect on the distance dimensions, maintaining them unchanged.

Since a microwave energy exposure time of three minutes, with a potency of 650W, could be considered as low potency, [19] it may be suggested that this technique does not cause distortion to the base when dentures are disinfected under these study conditions. Investigations to include complete dentures should be performed, however, to confirm this hypothesis.

Conclusion

Under the study conditions described herein, microwave energy disinfection does not alter the original linear dimensions of acrylic resin specimens.

Resumo

Este trabalho avaliou a alteração dimensional linear dos corpos-de-prova confeccionados a partir de matrizes retangulares de alumínio (65,0x12,0x3,5 mm), com 4 demarcações referenciais, sob influência das marcas de resinas acrílicas termopolimerizáveis Clássico, Onda-Cryl e QC-20. Padrões de cera medindo 67,0x15,0x5,0mm foram incluídos em muflas metálicas ou de plástico com gesso pedra, de acordo com a técnica convencional. Após presa do gesso, os padrões de cera foram retirados e as matrizes de alumínio moldadas nos moldes de gesso reembasados com silicone. A proporção pó/líquido e preparo da resina acrílica foram efetuadas de acordo com as recomendações dos fabricantes, sendo a prensagem da mufla metálica feita com auxílio do dispositvo RS de contensão. Após a polimerização em água aquecida a 74ºC por 9 horas, água em ebulição por 20 minutos ou por energia de microondas a 900 W por 10 minutos, os corpos-de-prova foram removidos das muflas após esfriamento até a temperatura ambiente e submetidos ao processo de acabamento convencional. As distâncias entre os pontos referenciais A-B, C-D, A-C e B-D foram mensuradas antes e após a desinfecção em microondas (650W por 3 minutos). A avaliação dimensional linear das distâncias foi efetuada com microscópio óptico comparador Olympus, com precisão de 0,0005 mm, por um mesmo operador. Os resultados obtidos submetidos à análise de variância e ao teste de Tukey em nível de 5% de significância mostraram que a desinfecção por microondas não alterou as dimensões originais dos corpos-de-prova.

Unitermos

Alteração dimensional linear; resinas acrílicas; desinfecção; microondas; teste de materiais; desinfecção de equipamento odontológico

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