Water Sorption of Heat-Polymerized Acrylic Resins Processed in Mono and Bimaxillary Flasks

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This study evaluated water sorption in heat-polymerized acrylic resins processed in monomaxillary flasks by water bath and in bimaxillary flasks by microwave energy and water bath. Fifty heat-polymerized acrylic resin specimens were fabricated according to the 12th specification of the American Dental Association and assigned to 3 groups: group 1 was processed by water bath in monomaxillary metallic flask; group 2 was processed by microwave energy in bimaxillary PVC flask; and group 3 was processed by water bath in bimaxillary metallic flask. Specimens were submitted to water sorption test, means were calculated and analyzed statistically by Student's t-test. Means (in g/cm^3) were: group 1 - 0.024085, group 2 - 0.025312 and group 3 - 0.022098. Microwave energy processing and the amount of stone and resin used in the bimaxillary PVC flask did not influence water sorption; specimens processed in bimaxillary metallic flask by water bath presented lower water sorption means, suggesting an inadequate polymerization of the acrylic resin mass.

Key Words: acrylic resin, flask, water sorption.

INTRODUCTION

Thermal polymerization of poly(methyl methacrylate) (PMMA) requires the presence of a heat source for activation of an initiator (benzoyl peroxide) (1). Currently, compressing mold technique followed by water bath (as a heat source) is the most commonly used method for acrylic resin processing.

Microwave energy has also been used as a heat source for heat-polymerized acrylic resins because acrylic resins processed this way keep the physical properties similar to those of conventionally processed resins (2,3). Therefore, use of polyvinyl chloride (PVC) flasks reinforced with glass fiber is necessary for denture inclusion leading to better results and improved polymerization quality (4).

However, acrylic resin processing methods do not avoid displacement of artificial teeth during denture inclusion and processing (5), which might increase occlusal vertical dimension due to production of premature contacts. It is hence necessary to adjust the oclusal surface of artificial teeth, which alters the occlusal anatomy, especially of posterior teeth. In addition, these alterations may cause mucosal injuries and affect the functionality of the prostheses, thus causing damage to the stomatognathic system, temporomandibular disorders and discomfort to the patient (6,7).

These aspects have been confirmed by studies investigating dimensional alterations due to acrylic resin polymerization. To overcome these problems, Souza HL developed a flask prototype named "HH flask" (*HH flask* - *Instrument used to minimize occlusal dislodges*

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in dentures. Rev Ass Paul Cirurg Dent 1987;41:270-274) that allowed the simultaneous inclusion of a pair of dentures in occlusion (8). This inclusion technique was claimed to save time and decrease occlusal alteration during denture processing. Based on the idea of this device and considering that processing by microwave energy is simpler, quicker and as efficient as water bath, Rizzati-Barbosa (9) developed a bimaxillary flask prototype similar to "HH flask", made of PVC reinforced with glass fiber for specific use in the microwave oven.

In addition to its polymerization shrinkage, which is inherent to the material and cannot be avoided, acrylic resin also presents water sorption (10) that is directly related to the polar properties of resin molecules, the physical process of water diffusion through intermolecular space (11) and the amount of residual monomer in the polymerized mass (12). Thus, polymerization degree is directly related to resin's ability of absorbing water. Heat generated during exothermic polymerization reactions or stone crystallization may influence this property. The higher amount of stone and acrylic resin used in the bimaxillary flasks may produce more heat and hence increase acrylic resin water sorption.

There are different opinions about water sorption effect on the dimensional stability of prostheses. Therefore, water sorption of acrylic resins processed by different methods should be assessed to determine which techniques are more advantageous for fabrication of dentures. The aim of this study was to evaluate water sorption in heat-polymerized acrylic resins processed in monomaxillary flask by water bath and in bimaxillary flask by microwave energy and water bath.

MATERIAL AND METHODS

Fifty heat-polymerized acrylic resin disc-shaped specimens were fabricated according to the 12th specification of the American Dental Association (13) by directly investing a stainless steel matrix in either mono or bimaxillary metallic flasks (DCL n.5.5; Bethil Com. Ltda., Campinas, SP, Brazil) or bimaxillary polyvinyl chloride flasks (Onda Cril; Clássico Artigos Odontológicos Ltda., São Paulo, SP, Brazil) (Fig. 1) using type III stone (Herodent-Soli-Rock; Vigodent SA Ind., Rio de Janeiro, RJ, Brazil).

After stone setting, the flasks were opened and the steel matrix removed. Sodium alginate coating (VIPI Coating; Dental VIPI Ltda., Pirassununga, SP, Brazil) was applied to stone surface and the heat-polymerized acrylic resins (Vipi Cril and Vipi Wave; Dental VIPI Ltda.) were prepared according to the manufacturer's instructions. The resins were packed into the flasks and put under pressure of 1.25 tons using hydraulic press. Polymerization procedures were carried out, as follows. Group 1 - 10 specimens were polymerized in monomaxillary metallic flasks by water bath (73ºC for 9 h); Group 2 - 20 specimens were polymerized in bimaxillary PVC flasks by microwave oven (Model MN 7806 BH – 1380 W, Panasonic, Manaus, AM, Brazil) (20 min/90 W and 5 min/450 W); and Group 3 - 20 specimens were polymerized in bimaxillary metallic flasks by water bath (73ºC for 9 h). The flasks were bench-cooled until reaching room temperature.

The specimens were deflasked and finished using tungsten drills and aluminum oxide sandpapers of decreasing granulations (#180, #220 and #400) at low speed. In order to obtain specimens with smooth surfaces and to apply the same pressure in different areas of each specimen, a cylindrical stainless steel support with a depression having the same size as that of the specimens was used (Fig. 2). Sample thickness was controlled using a digital pachimeter and sample volume (V) was calculated by taking 3 diameter measurements and 5 thickness measurements (one in the center and four equally spaced).

Water sorption test was conducted by placing the specimens in a recipient containing dry and fresh silica gel (Fig. 3), which was stored at 37 ± 1ºC during 24 h. Afterwards, the recipient was left bench-cooling

Figure 1. Polyvinyl chloride bimaxillary flasks used for polymerization in microwave oven.

for 1 h until reaching room temperature.

Specimens were weighted in an analytical balance accurate to 0.0001 g. This conditioning cycle was repeated every 24 h until all specimen weights (m_1) varied less than 0.2 mg during this period (13). Specimens were stored in distilled water at 37 ± 1ºC during 30 days, then removed from water, dried with paper towels and reweighed (m_2). Maximum weighing time was 60 s. Water sorption (g/cm^3) was calculated using the formula: water sorption = $(m_2 - m_1)/V$.

Data were submitted to statistical analysis by Student's t-test at 5% significance.

RESULTS

The water sorption means of group 1 (0.024085 g/cm^3) and group 2 (0.025312 g/cm^3) were statistically similar to each other ($p>0.05$) and both differed statistically from that of group 3 (0.022098 g/cm^3) ($p<0.05$). Groups 1 and 3 counted on the total number of specimens while group 2 counted on 19 samples because 1 specimen fractured during fabrication and was not included in statistical analysis.

DISCUSSION

Water absorbed by acrylic resin stays in gaps among the interpolymeric chains that form acrylic resin structure. The magnitude of these interpolymeric gaps determines the amount of water to be absorbed. Better polymerization of acrylic resin increases the crosslinking and reduces water sorption values. In this study, water sorption was evaluated for heat-polymerized acrylic resins processed by 3 different methods.

ISO 1567:2001 standard (Dentistry. Denture base polymers) recommends water sorption lower than 32 µg/mm^3, which was obtained in all three groups evaluated in this study. Within the established limit, water sorption can be considered a desirable property of the acrylic resins because it compensates resin polymerization shrinkage, improving denture adaptation clinically. However, beyond this limit, water sorption values can lead to undesirable dimensional alterations that may compromise denture clinical success and longevity.

No statistically significant difference ($p>0.05$) was found between the group fabricated using monomaxillary metallic flask plus water bath and the group fabricated using bimaxillary PVC flask plus microwave polymerization. This result is consistent with those of previous studies, which have also found that the quality of the polymerization obtained by microwave energy was similar to that obtained by conventional water bath technique (2,3). The findings of the present study suggest that microwave polymerization as well as the higher amount of stone and resin used for processing in bimaxillary PVC flask had no influence on water sorption. This can be explained by the fact that the microwave heating is dielectric, as the heat is generated in the mass to be polymerized. Polar molecules, like water and acrylic resin monomer, vibrate billions of cycles *per* second when exposed to microwave electromagnetic field. This vibration promotes intermolecular

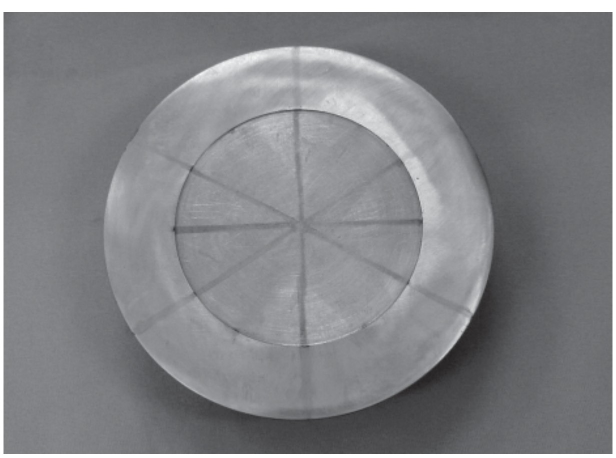

Figure 2. Cylindrical stainless steel support used for finishing procedures.

Figure 3. Recipient containing dry and fresh silica gel used during water sorption test.

shocks that generate homogeneous heat within the resin mass, resulting in an adequate polymerization (1). However, in this study, significant difference was found between the group fabricated using metallic bimaxillary flask plus polymerization by water bath and the other groups, the former presenting lower water sorption.

It is known that only water sorption test is not enough to evaluate the quality of acrylic resin polymerization. However, low water sorption values can indicate either a high quality polymerization, in which there is a higher amount of cross-linking between the interpolymeric chains (11) or a higher amount of residual monomer in the polymerized mass (12).

The higher amount of stone and resin used in metallic bimaxillary flasking may have affected the acrylic resin processing, since the heat offered by water bath is not as homogeneous as the dielectric type of heating offered by microwave energy. Thus, the heat offered by the water bath may not have been enough to promote an adequate polymerization of the acrylic resin mass, resulting in a higher amount of residual monomer. This influenced water sorption because, instead of water, the monomer occupies the gaps in the polymerized mass, which would explain the lower water sorption means (12). The lower water sorption means observed in group 3 could be explained by the fact that the polymerization of this group was not as satisfactory as that of groups 1 and 2. Further studies about residual monomer in acrylic resin specimens processed by the same technique are required.

Within the limitations of this study, the following conclusion can drawn: microwave energy processing and the amount of stone and resin used in the bimaxillary PVC flask did not influence water sorption; specimens processed in bimaxillary metallic flask by water bath presented lower water sorption means, suggesting an inadequate polymerization of the acrylic resin mass.

RESUMO

A finalidade deste estudo foi avaliar a sorção de água de resinas acrílicas ativadas termicamente quando processada em mufla monomaxilar para banho de água e mufla bimaxilar para banho de água e microondas. Foram confeccionados 50 corpos-de-prova de resina acrílica ativada termicamente de acordo com a especificação nº 12 da American Dental Asociation, divididos em três grupos: no grupo 1, os corpos-de-prova foram processados em mufla monomaxilar metálica para banho de água; no 2 foram processados em mufla bimaxilar de PVC para uso em microondas e no 3 foram processados em mufla bimaxilar metálica para banho de água. Os corpos-de-prova foram submetidos ao ensaio de sorção de água, os valores médios foram calculados e analisados pelo teste t de Student. Os valores obtidos (g/cm^3) foram: grupo 1 - 0,024085, grupo 2 - 0,025312 e grupo 3 - 0,022098. A polimerização da resina acrílica por energia de microondas na mufla bimaxilar de PVC não influenciou a sorção de água em relação ao processamento em muflas monomaxilares, enquanto a polimerização feita em muflas bimaxilares metálicas aquecidas em banho de água diminuiu esse índice, sugerindo inadequada polimerização da massa de resina.

REFERENCES

1. De Clerck, JP. Microwave polymerization of acrylic resins used in dental prosthesis. J Prosthet Dent 1987;5:650-658.
2. Nishii, M. Studies on the curing of denture base resins with microwave irradiation with particular reference to heat curing resins. J Osaka Univ Dent Sch 1968;2:23-40.
3. Rizzatti-Barbosa CM, Del Bel Cury AA, Panzeri H. Influence of water sorption and microwave polymerization on denture adaptability. Braz Oral Res (formerly Rev Odontol Univ S Paulo) 1995;9:197-206.
4. Kimura H, Teraoka F, Sugita M. Applications of microwave for dental technique (part 1) - dough-forming and curing of acrylic resin. J Osaka Univ Dent Sch 1983;23:43-49.
5. Holt JE. Research on remounting procedures. J Prosthet Dent 1977;83:338-341.
6. Barbosa DB, Compagnoni MA, Leles CR. Changes in occlusal vertical dimension in microwave processing of complete dentures. Braz Dent J 2002;13:197-200.
7. Yagi T, Marimoto T, Hidako O, Iwata K, Masuda Y, Kabayashi M, Takada K. Adjustment of the oclusal vertical dimension in bit raised guinea pig. J Dent Res 2003;82:123-130.
8. Rizzatti-Barbosa CM, Cunha VPP, Marchini L, Ribeiro MC. The influence of double flask processing in occlusal plane when a couple of dentures are processed in occlusal position. Braz J Oral Sci 2003;2:264-267.
9. Rizzatti-Barbosa CM. Flask for double enclosing in microwave oven (Prototype). Strict availability 03/23/2000; INPI:1938-1940.
10. Wong DMS, Cheng LYY, Chow TW, Clark RKF. Effect of processing method on the dimensional accuracy and water sorption of acrylic resin dentures. J Prosthet Dent 1999;81:300-304.
11. Takahashi Y, Chai J, Kawaguchi M. Effect of water sorption on the resistance to plastic deformation of a denture base material relined with four different denture reline materials. Int J Prosthodont 1998;11:49-54.
12. Dixon DL, Ekstrand KG, Breeding LC. The transverse strengths of three denture base resins. J Prosthet Dent 1991;66:510-513.
13. Sweeney WT, Paffenbarger GC. Tentative American dental association specification N. 12 for denture base material, acrylic resin or mixture of acrylic and other resins. J Am Dent Assoc 1941;28:325-328.

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