EFFECT OF RELINING ON THE MISFIT OF MICROWAVE-CURED ACRYLIC RESIN DENTURE BASES

EFEITO DO REEMBASAMENTO NA DESADAPTAÇÃO DE BASES DE PRÓTESES DE RESINA ACRÍLICA POLIMERIZADA POR MICRO-ONDAS

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ABSTRACT

Objective: The aim of this study was to evaluate the effect of microwave-energy polymerization on the accuracy and glass transition temperature of acrylic resin denture bases submitted to reline procedure. As denture wearers make up a large portion of the population and often cannot afford a new complete denture, the reline procedure may be the best alternative when indicated. Thus, it is important to evaluate possible changes that would contraindicate this technique. Materials and methods: Twenty denture bases were fabricated from microwave-cured acrylic resin (Onda-Cryl) and randomly divided into control and test groups (n = 10). In the control group, the bases were submitted to measurement of misfit. Bases in the test group were worn down internally and relined. Misfit was measured by cutting the set stone cast/denture base at three predetermined points (canine, molar and tuberosity), measuring the gap between the stone cast and the acrylic resin base at three points using the ImageTool®software suite. Differential scanning calorimetry was used to determine Tg. Data were submitted to t-test for independent-samples ($p<0.05$). Results: The greatest misfit of canine sections was found at the midpoint of control group (0.280 mm); in molar sections, no significant difference was found. In maxillary tuberosity sections, the greatest misfit occurred at the midpoint of test group (0.352 mm). All gaps were below the maximal clinically acceptable misfit value. There was no significant difference in Tg values between groups. Conclusion: Microwave-energy processing does not affect the fit or Tg of relined denture bases.

KEYWORDS: Polymethyl methacrylate; Polymerization; Denture rebasing; Transition temperature; Denture complete.

INTRODUCTION

The population of Brazil is aging, as are those of most countries, and older adults are proportionally the fastest-growing population segment. It is known that a significant number of older persons are edentulous, and this information is essential to support further research to ensure better quality of life for the elderly. Fully and, in some cases, partially edentulous patients can be rehabilitated through the use of removable partial or complete dentures fit to the residual ridge. The success of prosthodontic treatment, which includes ensuring comfort, restoring masticatory function and speech, and facilitating social integration, depends on close contact between the acrylic denture base and the residual ridge[1-4].

Acrylic resin has been used in the manufacture of denture bases since the late 1930s[5]. In view of its satisfactory performance and adequate physical, mechanical, and economic characteristics, it remains widely used in prosthetic rehabilitation[6,7]. The ideal condition is that the acrylic resin does not suffer distortion during its processing so that there is no maladjustment between the prosthesis and the oral mucosa.

Misfit between the denture base and the mucosa can be the result of two distinct situations: technical failure during prosthesis fabrication or the natural process of bone resorption. In the former case, a combination of polymerization shrinkage of acrylic resin, thermal contraction, and stress released during deflasking may result in denture base misfit[8-11]. In the latter case, continuous, progressive resorption of the alveolar process leads to topographical and structural changes in the supporting bone. The result is often loss of adaptation of the denture base, which causes physical discomfort and impairs masticatory function[2,3,12-14].

When this type of misfit is verified and all other requirements of a suitable prosthesis are present, such as aesthetics, vertical dimension, minimal artificial tooth wear, and stable occlusion, a relining procedure can be performed[15]. This technique enables recreation of the denture base to reestablish the desired fit[12]. A laboratory-based method using heat-cured acrylic resin is that most widely employed, as it results in better physical and mechanical properties for the denture base[16].

The use of microwave energy to cure acrylic resin was first reported in 1968 by Nishii, who evaluated base fit and some physical properties of the resin, comparing two polymerization methods: the conventional heated water bath method and a method using microwave energy[17].

Microwave curing is based on the principle that the electromagnetic waves produced by a magnetron generator form a nonionizing electromagnetic field within a conventional microwave oven[17]. It relates to the molecules' alignment with the applied electric field; when this field is removed, the molecules return to their position, in a disorganized manner, and this change in position is dissipated into heat. Thus, polar molecules of any substance which are under the action of this field will vibrate at a frequency of 2,450 MHz, resulting in material heating due to five billion intermolecular collisions per second[18].

In the microwave curing technique, the inner and outer surfaces of the material are heated uniformly; thus, the increase in temperature necessary for polymerization takes place in a shorter time[19]. Therefore, adaptation of the denture base to the residual ridge should be superior to that achieved with the conventional water bath method. In addition, polymerization of acrylic resins by microwave energy is faster, cleaner, and easier[20]. Another advantage is the control of polymerization time and the reduction of residual monomer content[21].

Other important property for evaluating the effect of a particular polymerization technique on acrylic resin is the glass transition temperature (Tg), as it can be affected if a large amount of residual monomer is present as a result of incomplete polymerization[22]. In addition, determining the Tg also enables estimation of polymer-polymer interactions in certain mixtures, and the presence of plasticizers in the polymer sample can lower the Tg value.

The techniques most commonly used for determination of Tg are differential scanning calorimetry (DSC) and dynamic mechanical analysis (DMA). After polymerization and before cooling of the acrylic resin, Tg reaches its peak and little stress is stored in the material, which is relatively flexible at this time. However, below the Tg, the material becomes rigid; as the denture base cools to room temperature, various stresses are induced by different rates of shrinkage in the resin and plaster model[12].

Studies evaluating the misfit of denture bases made from microwave-cured acrylic resin, with or without partial relining performed in the laboratory are very important because denture wearers covers a large portion of the population and often cannot afford a new complete denture. Therefore, the reline procedure may be the best alternative when indicated. Within this context, the objectives of this study were to evaluate the misfit of maxillary denture bases made from microwave-cured acrylic resin submitted to reline procedure, as well as determine the glass transition temperature of this resin.

MATERIAL AND METHODS

Specimen preparation

A metal model representing an edentulous maxilla was used to create 20 stone casts (type III gypsum, Dam-Proben, Cachoeirinha, RS, Brazil) from an impression prepared in two steps: heavy vinyl polysiloxane (Hydroxtreme, Vigodent, Rio de Janeiro, RJ, Brazil) followed by addition-cure silicone (Adsil Light Body, Vigodent, Rio de Janeiro, RJ, Brazil). These specimens were equally divided into test and control groups (Figures 1a and b)[4,8,11,16].

A denture base was prepared on each stone cast using two sheets of wax (NewWax, Technew, Rio de Janeiro, RJ, Brazil) softened in warm (45°C) water. The thickness of each base was approximately 3mm, as measured with a thickness gauge (Surmedix Ltd, Croydon, UK).

Each stone cast/wax base set was included in a fiberglass-reinforced plastic flask (Artigos Odontológicos Clássico Ltda, SãoPaulo, SP, Brazil) using type II gypsum (Dam Proben, Cachoeirinha, RS, Brazil). After setting, the flask was opened, the wax removed, and microwave-cured acrylic resin (Onda-Cryl, Artigos Odontológicos Clássico Ltda, São Paulo, SP, Brazil) poured in its place. A thin layer of mold release agent (Cel-Lak, SS White Art. Dentarios Ltda., Rio de Janeiro, RJ, Brazil) was applied before the acrylic resin, which was prepared according to the manufacturer's instructions, with a polymer/monomer ratio determined by weight (20g/10mL) on a precision balance (AUW model 220D, Shimadzu do Brasil, SãoPaulo, SP, Brazil) with 0.0001-g resolution. While in the plastic phase, the resin was manually poured into the flask, which was then placed in a bench press (Protecni, Araraquara, SP, Brazil) under 1,000 kg of load. The flask was kept in the press for 30 minutes as recommended by the manufacturer to achieve a uniform distribution of the load. The polymerization cycle used was 20 min at 10% power and 5min at 40%, in a microwave oven with a frequency of 2,450 megahertz (MHz) and power rating of 1,000 W (MB-315ML *intelloWAVE*, LG Electronics da Amazônia Ltda, Brazil).

Flasks were cooled on a laboratory bench at approximately 24°C for 4 hours before the finishing process, which consisted of the removal of acrylic resin flash around the denture base using a tungsten bur (Dhpro, Paranaguá, PR, Brazil). After finishing, the samples were randomly divided into test and control groups (n = 10 each). Control group bases were immediately measured for misfit, whereas test group dentures were relined before being evaluated for misfit.

Relining procedure

Test group specimens were weighed on a precision balance and their inner surfaces were worn down homogeneously, using a tungsten bur, by approximately 10% of the initial mass. The bases were then used as individual trays for a new impression of the metal maxilla, made using a light polyvinyl siloxane impression material, kept under a 2-kg load for approximately 5 minutes (Figure 2).

After this period, the set denture base/polyvinyl siloxane was removed from the metallic model and 100g of type III gypsum, made using the ratio recommended by the manufacturer, was poured onto the silicone surface. After the gypsum had crystallized (60 minutes), the set stone cast/denture base/polyvinyl siloxane impression was flasked, following the same procedures described above.

When the flask was opened, petroleum jelly residues and the polyvinyl siloxane film were removed, keeping the denture base in position. The same procedures described above for acrylic resin polymerization were carried out; however, in this group, the acrylic resin was applied onto the pre existing denture base.

Misfit measurement

At this stage, the set stone cast/acrylic resin denture base was removed from the flask, fit onto a cutting device, and sectioned at three points: I, anterior region of the palate; II, region of the first molars; and III, posterior region of the palate. These sections yielded four blocks, only the first three of which were of interest to this study: block 1 (canines), block 2 (molars), and block 3 (maxillary tuberosity) (Figure 3a and b).

Misfit between the acrylic resin base and stone cast was measured at three points on each block: on the crest of the right alveolar ridge (point 1), on the midline (point 2), and on the crest of the left alveolar ridge (point 3) (Figure 4).

Each section of the plaster model was photographed using a high-resolution professional digital camera, with the blocks and camera always placed in the same position. Measurements were performed on these images using the ImageTool software suite (Department of Dental Diagnostic Science, University of Texas Health Science Center, San Antonio, TX, USA).

Determination of glass transition temperature

the Tg (in °C) was determined by the differential scanning calorimetry (DSC) method. DSC evaluates the difference in heat flow between the sample and a reference as a function of system temperature as the sample is heated or cooled at a constant rate. Tg can predict the behavior of a material at a given temperature, since, at this temperature, the polymer chain segments are mobile and the material transitions from the glassy state to the rubbery state without causing a structural change. Below this temperature (Tg), the material does not have enough energy for displacement of chain segments to occur, and thus appears hard, rigid, and brittle.

For this analysis, five specimens from each group, sectioned after misfit measurements, were randomly selected, and a small portion of acrylic resin (10 mg) was obtained from the inner surface of each specimen. These small portions were inserted into aluminum capsules and subjected to a temperature range of 50°C to 190°C at a heating rate of 10 °C per minute in a DSC-4 calorimeter (Perkin Elmer, Beaconsfield, England). Tg was determined during the second heating cycle.

This study included a blinding procedure in which groups were identified by the supervising investigator, thus preventing identification by the examining investigator during testing.

RESULTS

The *t*-test for independent samples was used to compare mean misfit between the control and test groups, using the statistical program SPSS version 12.0, as shown in Table 1.

Comparison of the canine and tuberosity blocks showed a statistically significant difference between control and test groups at the midline point ($p=0.001$ and $p=0.03$, respectively). With respect to the molar region, there was no statistically significant difference between groups.

Tg results also showed no statistically significant difference between groups (Table 2).

DISCUSSION

Clinical evidence shows that when denture bases are readapted to the residual ridge, the rate of bone resorption can be decelerated[2]. Studies such as that by Barco et al. (1979) have confirmed that denture fit improves after a reline procedure. Furthermore, Tallgren et al. (1992) found a significant increase in chewing muscle strength and improvement in the temporal pattern of mastication after a reline procedure.

Polymethylmethacrylate (PMMA) is the only reliable material for denture base fabrication, due to its excellent physical properties, excellent esthetics, and low toxicity[25]. However,

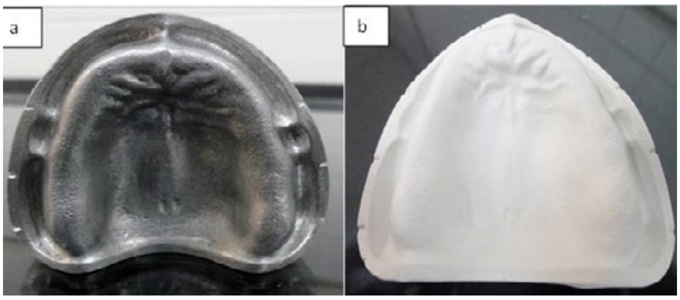

Figure 1 - a) Metal model representing an edentulous maxilla; b) Stone cast made from metal model.

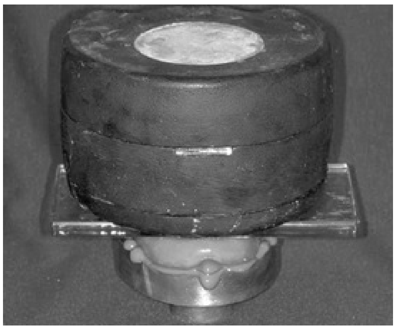

Figure 2 - Denture bases used for relining procedure.

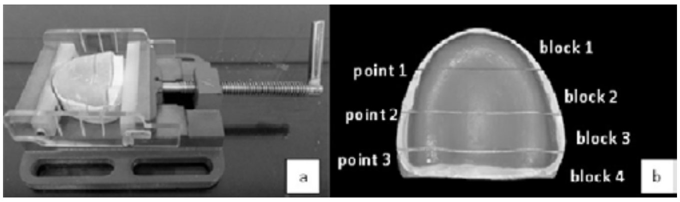

Figure 3 - a) Set stone cast/acrylic resin denture base fit into a cutting device; b) Set stone cast/acrylic resin denture base sectioned into four blocks.

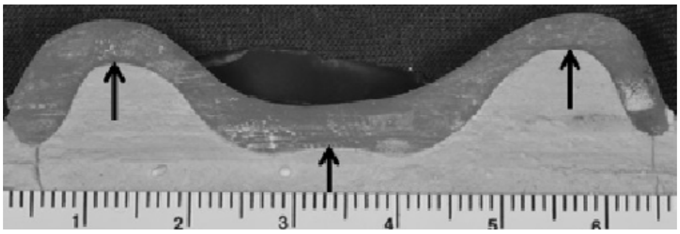

Figure 4 - Points at which misfit was measured, denoted by arrows.

Table 1 - Mean misfit values (mm) between control and test groups of canine, molar and tuberosity specimen blocks

GROUP Canine block	Point 1	p	Point 2	p	Point 3	p
Control	0.099^a	0.32	0.280^a	0.001	0.057^a	0.22
Test	0.058^a		0.032^b		0.117^a	
Molar block						
Control	0.083^a	0.36	0.183^a	0.23	0.039^a	0.11
Test	0.042^a		0.219^a		0.093^a	
Tuberosity block						
Control	0.037^a	0.41	0.246^b	0.03	0.048^a	0.88
Test	0.060^a		0.352^a		0.052^a	

Same letter along each column denotes no statistically significant difference ($p < 0.05$).

Table 2 - Mean glass transition temperature (Tg) values.

	Control Group	Test Group	p
Tg	103.45^a	103.83^a	0.41

Same letter along the line denotes no statistically significant difference ($p < 0.05$).

polymerization shrinkage and distortion of the denture base resulting from heat stress are unavoidable. These factors – combined with bone resorption, which is a continuous and progressive process – results in sites of denture base misfit in relation to the supporting mucosa[14]. It is well known that if a poorly adapted complete denture is worn for a prolonged period, a process of severe residual ridge resorption can be initiated, making denture use uncomfortable[13]. Poorly fitting prostheses are generally abandoned by their users.

The results of the present study showed different patterns of misfit when canine, molar, and maxillary tuberosity blocks were compared. In comparing the canine blocks, a statistical difference was observed at point 3, that is, at the point of curvature of the palate –a site of distortion of the acrylic resin, which tends to return from a curve to a flat position[3]. The highest misfit values were found in the control group. The reline procedure may have forced adjustment on these critical points by adding acrylic resin to the preexisting base.

Comparison of molar region blocks revealed no significant differences at any of the measured points, which demonstrates that the reline procedure using microwave-cured acrylic resin did not impair setting of the denture. In blocks from the maxillary tuberosity region, a significant between-group difference was found in point 2 (the midpoint), with the highest misfit value found in the test group.

Despite these statistical differences between the canine and tuberosity blocks at point 2, this finding is not clinically relevant, as a denture base is not adequately adapted to support tissues when there is a distance equal to or greater than 0.9 mm between the resin and the mucosa. In this study, the highest misfit value found was 0.3mm, showing that both groups would present clinically satisfactory fit to the mucosa.

Nishii (1968), who pioneered research into microwave polymerization of acrylic resins, evaluated the physical properties and fit of acrylic resin denture bases polymerized by the conventional and microwave methods, and no difference was found between these techniques[19]. In contrast, Takamata et al. (1989) reported lower misfit values with microwave curing compared to the heated water technique.

The use of microwave energy for denture repair and relining was reported by Turck et al.[24] (1992). According to the authors, this procedure can be performed perfectly in the microwave, with greater ease and less time, and resulting in more resistant prostheses with a longer service life[19]. In previous studies, the dimensional stability and fit of dentures polymerized with microwave energy were similar to those of dentures cured conventionally in a heated water bath[3,19].

The thickness of the denture base is a significant factor in the magnitude of contraction resulting from the polymerization process. The greater the thickness, the greater the contraction; consequently, the higher the distortion and, thus, the misfit. In the present study, the denture bases were approximately 3 mm thick to allow the inner surfaces to be worn down in preparation for the relining procedure. This may account for the misfit values found between the groups. Still, Skinner and Cooper[25] (1943) suggested that a lack of dimensional stability should be accepted as one of the disadvantages of dentures made from acrylic resins[6].

Thus, we can conclude that the use of microwave energy is a viable alternative for denture base polymerization, repair, and relining, as it does not cause significant dimensional changes. Several researchers have attempted to evaluate the properties of acrylic resins subjected to microwave polymerization, including hardness, tensile strength, sorption, and solubility, and have reported favorable results with this technique[6,14,17, 22].

Besides misfit, other important material properties should be evaluated, such as glass transition temperature (Tg). Tg is an important feature when considering polymeric materials because it directly influences their properties, so that when the Tg is reached, the acrylic resin passes from rigid solid to rubbery. The polymer passes from a rigid disordered state (vitreous) to a disordered state in which the polymer chains have greater mobility. This increases the movement of the polymer chains allowing them to slide over each other, resulting in material distortion. Below Tg, the polymer does not have sufficient internal energy to allow displacement of one chain relative to another.

In this study, the Tg of acrylic resin was evaluated by the DSC heat flow technique, in which the test sample and the reference sample are placed in identical capsules, positioned over a thermoelectric disc, and heated by a single heat source. No statistically significant differences were found in Tg values when comparing the control (103.45) and test (103.83) groups. Therefore, the relining procedure did not cause changes in the molecular structure of the acrylic resin and probably did not alter its properties. In addition, the Tg value found was clinically favorable; as it is exceedingly unlikely that a patient would ingest food or drink at this temperature, the prosthesis should remain in the desired vitreous state.

Therefore, relining of microwave-cured acrylic resin denture bases did not result in clinically significant misfit or change in Tg.

CONCLUSIONS

Within the limitations of this study, we conclude that:

a. The reline procedure using acrylic resin polymerized by microwave energy is highly recommended as it did not result in clinically relevant misfit, besides the advantages of being a simple and inexpensive procedure.
b. Across all comparisons, misfit values were less than 0.9mm, confirming the reliability of microwave polymerization for denture base relining procedures.
c. Tg was also unaffected, ensuring that there was no change in acrylic resin properties, making the reline procedure using microwave energy safe.

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RESUMO

Objetivo: Avaliar o efeito da polimerização utilizando energia de micro-ondas na adaptação e na temperatura de transição vítrea de bases de prótese submetidas ao procedimento de reembasamento. Uma vez que usuários de próteses totais constituem grande parte da população, o procedimento de reembasamento pode ser a melhor alternativa, quando indicado. Assim, se faz importante a avaliação de possíveis alterações que contraindicariam esta técnica. Materiais e Métodos: Foram confeccionadas 20 bases de prótese utilizando resina acrílica polimerizada por micro-ondas (Onda-Cryl) e divididas aleatoriamente em grupo controle e teste (n=10). No grupo controle as bases foram submetidas à mensuração da desadaptação. Já no grupo teste as bases foram desgastadas internamente e submetidas ao procedimento de reembasamento utilizando a mesma resina acrílica e a polimerização por energia de micro-ondas. A desadaptação foi mensurada por meio do corte do conjunto modelo de gesso/base de prótese, em três pontos pré-determinados, em ambos os grupos. Cada área seccionada foi mensurada em três pontos, utilizando o programa ImageTool®software. O ensaio de calorimetria exploratória diferencial foi utilizado para determinar a Tg em ambos os grupos. Os dados foram submetidos ao teste t para amostras independentes (p<0,05). Resultados: No bloco de canino, a maior desadaptação foi observada no ponto mediano do grupo controle (0,280 mm); no bloco de molares não houve diferença estatística entre os grupos. Já na comparação dos blocos de tuber, a maior desadaptação ocorreu no ponto mediano do grupo teste (0,352 mm). Apesar dos valores de desadaptação encontrados, nenhum foi igual ou superior ao valor máximo aceito clinicamente. Conclusão: A polimerização utilizando energia de micro-ondas não afetou a adaptação ou a Tg das bases de prótese submetidas ao reembasamento.

PALAVRAS-CHAVE: Polimetil Metacrilato; Polimerização; Reembasamento de dentadura; Temperatura de transição; Prótese total.

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