INFLUENCE OF DIFFERENT FLASKING AND POLYMERIZING METHODS ON THE OCCLUSAL VERTICAL DIMENSION OF COMPLETE DENTURES

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ABSTRACT

The flasking and polymerization technique for resins can introduce stresses during processing which may lead to denture base distortions, artificial teeth displacement and increases in the occlusal vertical dimension (OVD). This study investigated whether the association of microwave heat-activation (MH) and bimaxillary flasking (BF) minimizes the possible increases in OVD after prostheses processing. Forty pairs of complete dentures were waxed with the artificial teeth in closed occlusion and divided into four groups according to investing and heating methods: G1 (control) = monomaxillary/water bath; G2 = monomaxillary/microwave; G3 = bimaxillary/water bath and G4 = bimaxillary/microwave. OVD was measured using a digital caliper before and after prostheses processing. Results were submitted to statistical analysis (Student's t-test for multiple comparisons and post hoc ANOVA, α = 0.05). Comparison of values before and after processing showed that OVD increased in all groups after polymerization (p<0.001), regardless of flasking and polymerization methods. Statistically, G2 had the greatest difference in OVD when compared to G1 (p = 0.014), G3 (p = 0.019) and G4 (p = 0.024). G3 and G4 showed similar results statistically when compared to G1 (control). Both investing and heating methods resulted in an increase in OVD after processing. However, the prostheses invested in bimaxillary flasks showed the lowest changes in OVD, regardless of the polymerization method.

Key words: *Denture - complete - acrylic resins.*

INFLUÊNCIA DE DIFERENTES MÉTODOS DE INCLUSÃO E POLIMERIZAÇÃO NA DIMENSÃO VERTICAL DE OCLUSÃO DE PRÓTESES TOTAIS

RESUMO

Diferentes técnicas de polimerização de resinas acrílicas, bem como tipos de muflas para a inclusão, podem induzir tensões durante o processamento das mesmas, podendo gerar distorções da base de prótese, deslocamento dos dentes artificiais, e consequentemente gerar um aumento da dimensão vertical de oclusão (DVO). O objetivo deste estudo foi avaliar se a associação da energia de micro-ondas para ativação da resina acrílica (MH) com muflas bimaxilares (BF) minimiza os possíveis aumentos DVO após o processamento das próteses. Para isto, quarenta pares de próteses foram enceradas com os dentes artificiais em oclusão e divididas aleatoriamente em quatro grupos, de acordo com os tipos de mufla para inclusão (mono e bimaxilares) e aquecimento da resina (microondas e banho de água): G1 (controle) = monomaxilar / banho água; G2 = monomaxilar / microondas; G3 = bimaxilar / banho água e G4 = bimaxilar / microondas. A medida de DVO foi determinada utilizando um paquímetro digital, antes e após o processamento das próteses. Os resultados foram submetidos à análise estatística (ANOVA e teste t de Student, α = 0,05). Comparando os valores antes e após o processamento, todos os grupos apresentaram um aumento na DVO após a polimerização (p <0,001), independentemente do tipo de mufla e método de polimerização. Estatisticamente, o G2 apresentou o maior valor da diferença de DVO quando comparado ao G1 (p = 0,014), G3 (p = 0,019) e G4 (p = 0,024). G3 e G4 apresentaram resultados semelhantes estatisticamente quando comparado com G1 (controle). Tanto o método de inclusão (muflas mono e bimaxilares) como de aquecimento (microondas e banho de água) influenciaram para um aumento da DVO após o processamento. No entanto, as próteses incluídas em muflas bimaxilares apresentaram os menores valores de alterações na DVO, independentemente do método de polimerização (aquecimento).

Palavras-Chaves: *Resina acrílica - prótese total.*

INTRODUCTION

Several factors are involved in satisfactory rehabilitation using complete dentures, in both young and elderly patients. These include the patient's general health; the height, thickness and quality of residual alveolar bone and gingiva; muscle pattern and the technical quality of the laboratory. The compromise of any of these factors can cause treatment failure, complicating the process of adapting to a new prosthesis, especially in elderly patients[1].

During denture fabrication, poly(methylmethacrylate)-based (PMMA) resin undergoes unavoidable distortions[1] such as thermal expansion and contraction due to heating[2]. Dimensional changes caused by PMMA distortion can promote tooth displacement and consequently, alterations in the occlusal vertical dimension (OVD)[3,4]. This may lead to traumatic occlusion, irregular distribution of dental stresses on the residual alveolar ridge, masticatory inefficiency, discomfort, and subsequent difficulty in adapting[5-7].

PMMA studies have been carried out mainly to manage the investing procedures and resin heating in order to optimize the results and to keep denture base alterations under control[7,8]. Microwave heat-activation (MH) has been used to polymerize denture resins due to its feasibility, speed and efficiency [7,9-11] compared to conventional curing (water bath). However, like warm water bath heat-curing, MH does not prevent denture base distortion or artificial teeth displacements[12,13].

A new method has been suggested to minimize this problem: investing and polymerizing both prostheses simultaneously, with upper and lower artificial teeth in closed occlusion. This process uses a bimaxillary flask (BF) designed for the purpose, in which maxillary and mandibular dentures are invested and processed at the same time[11]. Preliminary studies have been performed to verify that investing prostheses in a BF can be associated with processing the resin by MH without causing any damage[7,14]. The results of these studies show that this association does not alter the surface roughness, hardness or surface porosity of the acrylic resin and is an efficient techinique[7,14]. However, it has not been verified whether the MH/BF association can really hold the position and occlusion of artificial teeth and consequently reduce tooth displacements and OVD alteration[11].

Thus, the aim of this study was to evaluate whether the association of MH and BF can help prevent increases in OVD after the processing of complete dentures, in comparison to conventional warm water bath heating and monomaxillary flasking methods.

MATERIAL AND METHODS

Group distribution and duplication cast

The specimens were distributed into four groups (n = 10) according to flask type and polymerization method (Table 1).

One complete edentulous maxillary and one complete edentulous mandibular master cast no retentive shaped to facilitate removal after investment were fabricated in type IV stone (Herostone, Vigodent, Rio de Janeiro, Brazil) and used to produce one maxillary and one mandibular addition-cure silicone mold. They were marked with a cross that was reproduced in a glass container with a magnetic plate in the center, into which a magnet was inserted. To produce forty pairs of maxillary and mandibular stone casts, type III stone (Herodent, Vigodent, Rio de Janeiro, Brazil) was poured into the addition-cure silicone mold and the glass container was immediately placed on the mold so the cross-shaped marks overlapped. Thus, all forty pairs of type III stone casts contained a magnet in their base, allowing perfect and equal fitting of all the casts into the magnetic plate.

Articulator mounting and waxing teeth

All stone casts were placed in a vacuum forming machine (MetalVander, Piracicaba, São Paulo, Brazil) and 2 mm soft ethylene-vinyl acetate (EVA) material (BioArt Equipamentos Odontológicos, São Carlos, São Paulo, Brazil) was used to produce standardized denture bases for all pairs of maxillary and mandibular complete dentures.

Wax rims were fabricated according to an idealized anteroposterior curve over one extra pair of stone casts with their respective EVA denture base. This extra pair of stone casts was mounted on a semi-adjustable articulator (SAA) by placing the mandibular stone cast with its denture base directly on the magnetic plate of the SAA lower element and positioning the maxillary stone cast with its denture base on top of it. The space between the maxillary stone cast and the magnetic plate of the upper element of the SAA was filled with type IV stone (Herostone, Vigodent, Rio de Janeiro, Brazil) to provide a random occlusal vertical dimension (OVD).

Table 1: Group distribution according to flask, acrylic resin and polymerization method.

Group	Flask	Acrylic resin	Polymerization method
G1 (control)	Monomaxillary	VipiCril	Water bath
G2	Monomaxillary	VipiWave	Microwave
G3	Bimaxillary	VipiCril	Water bath
G4	Bimaxillary	VipiWave	Microwave

Next, this pair of denture bases and wax rims was polymerized using heat-activated acrylic resin invested in metallic monomaxillary flasks, following the manufacturer's instructions (Vipi Cril, VIPI, Pirassununga, São Paulo, Brazil). These acrylic devices were used to mount all pairs of maxillary and mandibular stone casts on the SAA and standardize the arrangement of the artificial teeth.

Thus, after mounting each pair of stone casts on the SAA, the lower acrylic device was placed on each mandibular stone cast and the respective EVA denture base was placed on the matching maxillary stone cast, allowing maxillary wax rims to be fabricated accordingly. The same procedure was carried out to fabricate all mandibular wax rims, except that the upper acrylic device was placed on each maxillary stone cast and the respective EVA denture base was placed on the matching mandibular stone cast. At this point, all forty pairs of complete edentulous maxillary and mandibular stone casts were ready for the arrangement of the artificial teeth.

The lower acrylic device was then kept in position against the maxillary denture base and the wax rim and upper artificial teeth (H3/M3S, Trilux-Ruthibrás, Sao Paulo, Brazil) were arranged accordingly. The acrylic device was replaced by the mandibular denture base and the wax rim and lower artificial teeth (K3/M3I, Trilux-Ruthibrás, Sao Paulo, Brazil) were arranged in tightly closed occlusion. At the end of these procedures, the forty pairs of complete dentures were randomly assigned to the one of the four experimental groups (Table 1).

OVD measurements

The first measurement of the OVD was performed by placing the SAA in a wooden device designed specifically for the fitting of its lower element. A digital caliper (Starret, Sao Paulo, Brazil) was used to measure the distance between the upper and lower elements of the SAA for each pair of complete dentures.

Investing and Polymerizing Procedures

The waxed complete dentures were invested either separately in monomaxillary flasks (G1 and G2), or simultaneously and with teeth in closed occlusion (Fig. 1) in bimaxillary flasks (G3 and G4) (Fig. 2), according to the group assignment (Table 1). Heat-activated acrylic resins (Vipi Cril and Vipi Flash, VIPI, Pirassununga, São Paulo, Brazil) were prepared according to the manufacturer's instructions, and polymerized complete dentures were made either using warm water bath (curing cycle: 9h at 73°C) (G1 and G3) or microwave energy (G2 and G4) (curing cycle: 20 min at 180W/5 min at 540W), according to the experimental design.

After processing and cooling the flasks to room temperature, complete dentures and stone casts were carefully removed from the flasks. Since a fractured model could compromise the articulator mounting and thus the OVD measurements, any fractured models were discarded, and the whole procedure was repeated to make a new specimen. Each pair of complete dentures was properly remounted on the SAA and a second OVD measurement performed using the same procedure as the first measurement.

The difference between OVD measurements before and after processing the pairs of complete dentures was obtained and a Kolmogorov-Smirnov test was performed to confirm that the means were normally distributed ($\alpha = 0.05$). All groups had normal distribution, homogeneous group variances, independent data and the same number of specimens per group. Student's t-test for multiple comparisons (within and between groups) was used as a *post hoc* ANOVA (α=0.05).

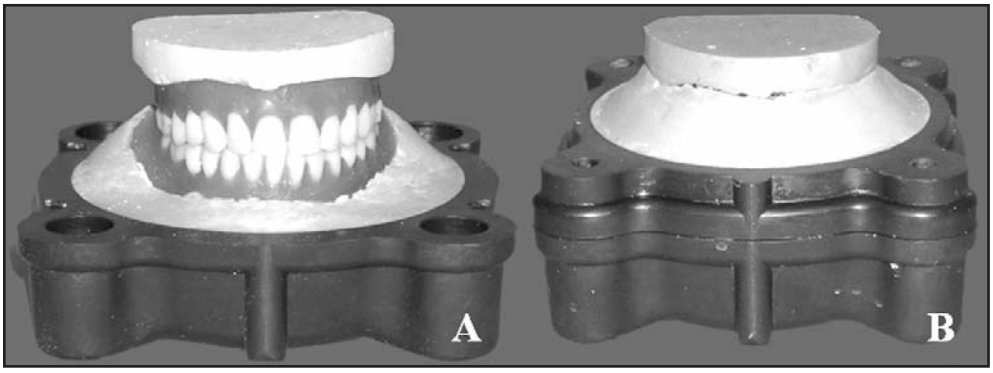

Fig. 1: Teeth in closed occlusion (A) and invested in bimaxillary flask (B).

RESULTS

All groups showed some increase in OVD after polymerization of the complete dentures, regardless of the flasking and polymerization methods ($p<0.0001$) (Table 2). The mean and standard deviation (mm) of the OVD before and after polymerization and standard deviations (mm) were 2.50 ± 0.71 for G1, 3.46 ± 0.53 for G2, 2.55 ± 0.51 for G3, and 2.57 ± 0.89 for G4 (Table 2).

Polymerization of complete dentures simultaneously in bimaxillary flasks either by warm water bath (G3) or microwave energy (G4) proved to be as efficient as conventional polymerization in monomaxillary flasks by warm water bath (G1). Polymerization of complete dentures in monomaxillary flasks by microwave heat activation (G2), however, had the greatest difference in values, differing significantly from G1, G3, and G4 (Table 3).

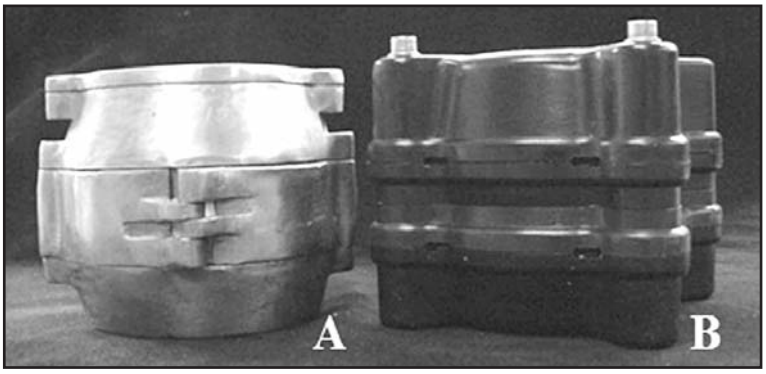

Fig. 2: Bimaxillary flasks used in the water bath (A) and microwave (B) curing processes.

Table 2: Difference (mm) in Occlusal Vertical Dimension before and after polymerization.

Group	Before Mean sd.	After Mean sd.	Difference Mean sd.	p value
G1	118.59 A ± 0.26	121.08 B ± 0.79	2.50 ± 0.71	< 0.0001
G2	118.37 A ± 0.21	121.83 B ± 0.60	3.46 ± 0.53	< 0.0001
G3	118.42 A ± 0.34	120.97 B ± 0.90	2.55 ± 0.51	< 0.0001
G4	118.55 A ± 0.26	121.12 B ± 0.95	2.57 ± 0.89	< 0.0001

Sd: standard deviation.
Different letters (horizontal) indicate statistical significance ($p<0.05$) – Student's t test

DISCUSSION

Changes due to the processing of complete dentures are common and may cause alterations in the OVD[15,17]. These changes can compromise the esthetics, phonetics, adaptation and retention of the prostheses[1]. For the elderly, these changes may ultimately result in longer periods of adaptation and patient dissatisfaction[1,18].

The choice of flasking method has long known to be crucial to prevent alterations in OVD, especially due to its association with changes in the artificial teeth positioning[19]. Regardless the type of flasking or polymerization method, in our study, all groups had increased OVD after the processing of the complete dentures. Previous studies evaluating alterations in OVD of prostheses processed under different conditions have reported similar results[12,13,19,20]. This is probably due to unavoidable dimensional changes that are intrinsic to acrylic resins during their processing, such as thermal heating expansion, cooling contraction, and polymerization shrinkage[12,15]. These changes can distort the denture base and modify the position of artificial teeth, resulting in increased OVD[21,22].

The association proposed in this study (double flasks and microwave energy) has demonstrated that polymerizing complete dentures using double flasks, whether by conventional warm water bath or by microwave energy, is as efficient as polymerizing the pair of prostheses separately in metallic monomaxillary flasks by warm water bath (control).

Table 3: Student's t-test of OVD differences comparing the groups after polymerization.

Comparison between groups	OVD difference (mm)	p value
G1 X G2	0.960	0.014
G1 X G3	0.050	Ns
G1 X G4	0.070	Ns
G2 X G3	0.910	0.019
G2 X G4	0.890	0.024
G3 X G4	0.020	Ns

Ns – No significant; P>.05

The PVC double flask for microwave irradiation, which allows simultaneous packing of the pair of complete dentures in maximal occlusion, can probably minimize occlusal changes that can be generated by the dimensional alterations inherent to the acrylic resin polymerization[11]. Indeed, previous studies that have reported greater alterations in arti-

ficial teeth positioning with microwave heating did not use the double flasking method, and therefore did not keep teeth tightly occluded[19,20,23,24].

It has also been suggested that prostheses invested in double flasks may be highly distorted due to the larger amount of acrylic resin in the flask, especially those invested in PVC double flasks, which would also be submitted to the harmful effects of the abrupt heating provided by microwave energy[3,7]. However, both double flasking methods resulted in OVD increases that did not differ from those observed in the prostheses processed by the conventional method, regardless of heat-activation method. Previous studies by our group have proven that other mechanical properties of the acrylic resin are not harmed by double flasking methods[7,14].

Accordingly, we have observed that processing the pair of prostheses separately in monomaxillary flasks using microwave energy can have greater impact on the increase in OVD, suggesting that the abrupt heating it provides can significantly impair the clinical outcome.

Although the use of microwave energy to polymerize acrylic resins has produced some contrasting results, it offers the advantage of time saving with somewhat cleaner processing equipment and handling compared to the conventional water bath method[7,8]. Additionally, microwave heating can polymerize the resin quickly and efficiently, maintaining all mechanical properties within the ADA recommendations[14,25].

Although the association of double flasking and microwave energy heating is relatively new in dentistry and few studies have aimed to evaluate this technique, it has so far been proven to work as well as the conventional method[26]. Since it can be quicker, easier, cleaner, and has recently been shown to reduce changes in artificial teeth positioning[23], we would strongly recommend it.

CONCLUSIONS

The increase in OVD of complete dentures promoted by characteristics intrinsic to the polymerization of acrylic resins is not affected by the use of bimaxillary flasks, regardless of the heat-activation method, compared to the conventional metallic monomaxillary flasking followed by warm water bath method. However, the processing of prostheses in PVC monomaxillary flasks followed by microwave heat activation can significantly exacerbate this unavoidable increase in OVD.

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