EFFECT OF POLYMERIZATION TECHNIQUES ON VERTICAL DIMENSION AND TOOTH POSITION IN COMPLETE DENTURES

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ABSTRACT

Due to the changes in the composition and processing of acrylic resins, it seems appropriate to evaluate the influence of polymerization methods about the alteration of occlusal vertical dimension and the horizontal positioning of artificial teeth of total dentures. For this, 64 specimens were made, simulating a maxillary total denture waxed from a standard maxillary denture. The experimental samples were divided into two groups: Group 1 - The resins were submitted to polymerization in a hot water bath, Group 2 - The same resins were submitted to polymerization by microwave energy. The samples were measured horizontally and vertically before and after the polymerization process. Based on the results, it can be concluded that there was no statistically significant difference between the conventional polymerization method and the polymerization method by microwave, related to the stability of occlusal vertical dimension and horizontal positioning of artificial teeth on the specimens evaluated.

Key words: acrylic resins, dentures, polymerization.

EFEITO DO MÉTODO DE POLIMERIZAÇÃO DE RESINAS ACRÍLICAS NA DIMENSÃO VERTICAL E POSICIONAMENTO DENTAL EM PRÓTESES TOTAIS

RESUMO

Devido às modificações na composição e processamento das resinas acrílicas, julgamos oportuno avaliar a influência do método de polimerização por microondas sobre a alteração da dimensão vertical de oclusão e sobre o posicionamento horizontal dos dentes artificiais das próteses totais, quando comparados ao método de polimerização convencional. Para isto, foi fabricado uma matriz padrão em silicona, e a partir dessa matriz, foram confeccionados 64 corpos-de-prova correspondentes ao modelo superior desdentado total com a base de prova encerada e os dentes artificiais montados. As amostras experimentais foram divididas em dois grupos: Grupo 1 – As resinas foram submetidas à polimerização por banho em água quente, Grupo 2 – As mesmas resinas foram submetidas à polimerização através da energia de microondas. Os corpos-de-prova foram mensurados nos sentidos horizontal e vertical antes e depois da polimerização das próteses totais superiores. Com base nos resultados das leituras e análise estatística dos valores, pode-se concluir que não houve diferença estatística significante entre o método de polimerização convencional e o método de polimerização por microondas, relacionados a estabilidade da dimensão vertical de oclusão e ao posicionamento horizontal dos dentes artificiais nos corpos-de-prova avaliados, da mesma forma, também não houve diferença entre o comportamento das diferentes resinas submetidas aos métodos de polimerização.

Palavras chaves: resina acrílica, prótese total, polimerização.

INTRODUCTION

Poly (methyl methacrylate) is a resinous base most frequently used in total prostheses (dentures) and in biomedical applications[1]. Its processing can be made through different methodologies[2], including conventional polymerization (by immersion in hot water) and microwave-based polymerization. When compared to the conventional technique, microwave polymerization has the following main advantages: dramatic decrease in polymerization time[3], hygiene at workplace[4], decrease in internal porosity of the resin[5], and, as per Al-Hanbali et al.[6], and Wallace et al.[7], an improvement in dimensional stability as well as a greater conversion of the monomer into a polymer[8]. One of the reasons suggested for improving dimensional stability could be the homogeneous heating of the cast used in the embedding and of the acrylic resin, when microwave power is used, which produces less internal stress in the resin[9].

The polymerization technique of acrylic resins through microwave power, as described by De Clerck[10], shows that it differs from conventional thermal energy in that heat expands from the inner area towards the outer area. Barbosa et al.[4], stated that the great advantage of microwave heating over conventional heating is the rapid increase in tempera-

ture. Microwave power promotes the movement of water molecules present in the cast of the embedding in a rate of about 2 to 3 billion times per second[11], thus increasing the heating level of the acrylic resin and, consequently, producing its polymerization in a short time.

Thus, although the contraction of acrylic resins through polymerization occurs irrespective of the method being used, the techniques that resort to microwave power have been recommended instead of conventional hot water polymerization techniques[4,12]. The processing method and the thickness of the acrylic resin layer in denture are important factors that may cause dimensional changes in this material[4], and in the placement of artificial teeth in total prostheses[13].

When extrapolating this situation to the odontological clinical field, one of the implications would be the increase in the dimension of the vertical occlusion in patients and the change in the placement of the teeth of the prosthesis, which requires reassembly and occlusal adjustment procedure. This change can be verified through the horizontal and vertical linear measurements that are present mainly in the maxilary denture.

Previous research[4,12,14] has comparatively assessed conventional polymerization and microwave-based polymerization techniques. Nevertheless, no research was identified in which comparisons were made of different brands of acrylic resins subject to conventional and microwave-based polymerization. The main differences between commercial brands of acrylic resins are the alterations in their chemical formulation and significant differences in terms of cost. Considering the scarce scientific bibliography that links the influence of different polymerization methods and of different acrylic resins with changes in occlusal vertical dimensioning and with the placement of artificial teeth by simulating a clinical practice, and considering the advantages of microwave-based polymerization over conventional polymerization, the purpose of this research was to comparatively assess the impact of both conventional and microwave-based techniques on the alteration of the occlusal vertical dimension and on the placement of artificial teeth of the dentures by using different commercial brands of acrylic resins.

MATERIALS AND METHODS

Based on a standard technique, 64 total maxillary dentures were made and randomly organized into 8 trial groups (n=8), as shown in Table 1. In this trial, the following acrylic resins were used: QC 20 (Dentsply Ind. Com., Brazil), Termo Clear (Dentbras Ind. Com. Ltd., Brazil) and Clássico (Artigos Odontológicos Clássico Ltd., Brazil), recommended by their manufacturers for conventional polymerization, and acrylic resin Onda-Cryl (Artigos Odontológicos Clássico Ltd., Brazil) recommended for microwave polymerization. Notwithstanding, according to Table 1, all the acrylic resins were polymerized both through conventional method and through microwave method.

Table 1. Description of acrylic resins and of polymerization cycles.

Commercial Brand	Batch N°	Manufacturer	Powder/ Liquid Ratio (g/ml)	Polymerization Cycle (Group A)	Polymerization Cycle (Group B)
Clássico	Powder: 015070 Liq: 111206	Artigos Odontológicos Clássico Ltd., Brazil	22.0/8.25	Conventional Double-Boiling 73°C for 3h + 100°C for 30min	Microwave Power 500W for 3min [9]
Onda - Cryl	Powder: 125070 Liq: 010208	Artigos Odontológicos Clássico Ltd., Brazil	22.0/8.25	Conventional Double-Boiling 73°C for 3h + 100°C for 30min	Microwave Power 320W for 3min + 0W for 4min + 720W for 3min*
QC 20	Powder: 678939 Liq: 580313	Dentsply Ind Com Ltd., Brazil	23.0/10.0 22.0/10.2	Conventional Double-Boiling 73°C for 3h + 100°C for 30min	Microwave Power 500W for 3min [9]
Termo Clear	Powder: 86404 Liq: 71171	Dentbras Ind Com Ltd., Brazil		Conventional Double-Boiling 73°C for 3h + 100°C for 30min	Microwave Power 500W for 3min [9]

* Cycle recommended by Ondacryl manufacturer.

Preparation of Dentures

Standardized waxed prostheses were prepared by using the methods described by Barbosa et al.[4]. For this, 64 cast models (Herostone Vigodent S/A Ind. Com. Ltd., Brazil) of toothless jaws were made from a silicone SM matrix (Silicona Master, Talladium do Brasil Prod. Prótese Dentária Ltd., Brazil). The supports for a double total prosthesis were set up by using a semi-adjustable Whip-Mix articulator and the artificial teeth (Biotone, Dentsply Ind. E Com. Ltd., Brazil) were duly placed in maximum intercuspation so that lingual cuspids of maxillary teeth would occlude with the central fossa and the marginal ridge of the mandibular teeth. Firstly, the mandibular dentures was processed through conventional procedures and reassembled on the articulator. Then, occlusal adjustments were made only on inferior teeth. The same mandibular dentures was used for all the trial groups for a standardized reproduction of the waxing of the maxillary dentures. An SM silicone matrix (Silicona Máster, Talladium do Brasil Prod. Prótese Dentária Ltd., Brazil) was obtained from the first waxed maxillary dentures (Fig. 1).

For the assembly of the superior teeth, artificial teeth 263/30M were used (Biotone, Dentsply Ind. e Com. Ltd., Brazil) and placed inside the silicone matrix, and two sheets of Nº 7 wax (Clássico, Artigos Odontológicos Clássico Ltd., Brazil) were melted and poured into the matrix and, on top of that, the cast model previously obtained was placed. After 30 minutes, the maxillary denture was removed from the matrix and assembled on the Whip-Mix articulator, using the maximum intercuspation as a reference. The vertical dimension of the occlusion was determined by the contact of the incisal pin on the incisal table.

Vertical Measurements

Vertical measurings were made by using a digital pachymeter (Mitutoyo, Mitutoyo Corporation, Japan), with a reading accuracy of 0.01 mm, perpendicularly fixed on the support table where the semi-adjustable articulator with the dentures had been placed (Fig. 2). With this device, measurings were made before and after the polymerization of the dentures. The pachymeter was set to zero between each measuring procedure and these procedures were replicated three times on different occasions[12]. From this data, the arithmetical average was obtained from each specimen before and after the polymerization procedures. Measurements were always taken by the same investigator. Thus, alterations in the occlusion vertical dimension were obtained from the difference between the initial and the final measuring.

Horizontal Measurements

After obtaining the waxed maxillary dentures, drills were made with a 701 drill (JET Carbide Burs Ltd., Brazil), in low rotation, in specific points for six follow-ups: A (distance between the mesial surface of the disto-vestibular cuspid of the 1º. right molar and the right canine cingulum), B (distance between the right canine cingulum and the left canine cingulum), C (distance between the left canine cingulum and the mesial surface of the disto-vestibular cuspid of the 1º. left molar), D (distance between the mesial surface of the disto-vestibular cuspid of the 1º. right molar and the mesial surface of the disto-vestibular cuspid of the 1º. left molar), E (distance between the mesial surface of the disto-vestibular cuspid of the 1º. right molar and the cingulum of the right central incisor), and F (distance between the mesial surface

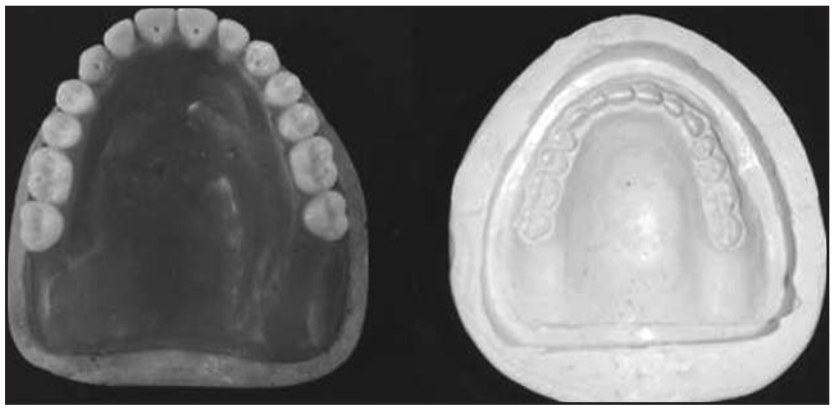

Fig. 1: Waxed superior denture and silicone mold.

Fig. 2: Maxillary and mandibular denture assembled as per ASA

of the disto-vestibular cuspid of the 1º. left molar and the cingulum of the left central incisor), as shown in Fig. 3. Distances were measured by means of a digital pachymeter (Mitutoyo, Mitutoyo Corporation, Japan), with a reading accuracy of 0.01 mm. These measurings were made before and after the polymerization of the dentures and, as with the vertical measurings, the pachymeter was set to zero between each measuring and these were replicated three times[12]. With this data, the arithmetical average of each specimen was also obtained. Measurements were always taken by the same investigator. Thus, alterations in the dental placement were obtained by the difference between the initial and the final measuring.

Processing of Specimens

Half of the waxed prostheses were placed in the metal muffles (MAC Artigos Odontológicos e Prótese Ltd., Brazil) and the remaining half was placed in fiberglass-reinforced plastic muffles (Dental Vipi Ind. Com. Ltd., Brazil). The specimens were placed under a hydraulic pressure equal to 1000 kg/f (VH, Essence Dental Ltd., Brazil) until contact between the superior and inferior parts of the muffles was attained. The specimens were included in three investment layers[4]. After the wax was removed, the acrylic resins were handled as per manufacturers' instructions. Immediately after this, a test compression was performed[14,15], with a hydraulic pressure equal to 500 kg/f (VH, Essence Dental Ltd., Brazil) to promote contact between the superior and inferior parts of the muffles and to remove resin in excess. After the opening of the muffles, the excess of resin was removed and the muffles were gradually subject to hydraulic pressure until a stable level of compression of 1000 kg/f [14] was attained. This was kept during 30 minutes. Soon after this, the specimens were subject to the polymerization cycles described in Table 1. After completion of the polymerization procedures, of cooling down at room temperature during 24 hours[16] the maxillary denture was removed and the dentures wererepositioned in the semi adjustable articulator using the split-cast technique[17] to foster standardization of the final measurements. With the specimen already polymerized and duly reassembled on the articulator, final vertical and horizontal measurements were performed, as mentioned above.

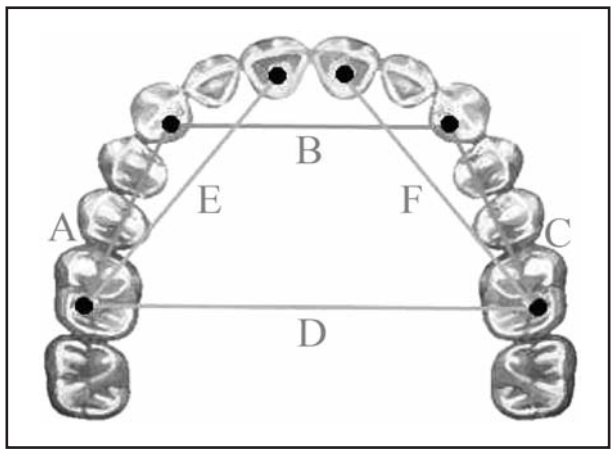

Fig. 3: Standard denture with points and segments selected for the measurings.

Statistical Analysis

Data were analyzed by means of software Bioestat 5.0 and of the Kruskal-Wallis test, and the comparison of averages resulted in a level of confidence of 95% ($p<0.05$).

RESULTS

The averages of changes in the vertical dimension and in the dental placement in the different groups and their corresponding standard deviation are shown in Tables 2 and 3. For changes in the vertical

Table 2. Changes in vertical dimension.

Commercial Brands	Polymerization Methods							
	Microwave Power				Conventional			
	QC 20	Clássico	Onda - Cryl	Termo Clear	QC 20	Clássico	Onda - Cryl	Termo Clear
Vertical Changes (mm)	0.39 ± 0.60	0.36 ± 0.50	0.56 ± 0.75	-0.04 ± 0.69	0.73 ± 0.24	0.77 ± 0.60	0.48 ± 0.88	0.44 ± 1.13
Vertical Changes (%)	0.27 ± 0.44	0.24 ± 0.37	0.45 ±0.48	-0.02 ± 0.46	0.50 ± 0.16	0.52 ± 0.41	0.33 ± 0.60	0.30 ± 0.76

Values are expressed as mean ± standard deviation

Table 3. Changes in dental placement.

Commercial Brands	Polymerization Methods							
	Microwave Power				Conventional			
	QC 20	Clássico	Onda - Cryl	Termo Clear	QC 20	Clássico	Onda - Cryl	Termo Clear
Horizontal Changes (mm)	0.06 ± 0.09	-0.01 ± 0.07	-0.02 ± 0.11	0.08 ± 0.04	-0.204 ± 0.05	-0.04 ± 0.08	-0.06 ± 0.05	0.00 ± 0.08
Horizontal Changes (%)	0.22 ± 0.34	-0.10 ± 0.29	-0.07 ±0.10	0.31 ± 0.15	-0.19 ± 0.14	-0.06 ± 0.10	-0.08 ± 0.19	0.18 ± 0.24

Values are expressed as mean ± standard deviation

dimension, values obtained varied from -0.04 mm, for acrylic resin Termo Clear, polymerized by microwave energy, to 0.77 mm, for acrylic resin Clássico, polymerized by microwave energy and hot water. There were no statistically significant differences among the groups subject to the tests.

Data obtained for the six follow-ups measured to detect changes in the placement of artificial teeth in the experimental groups varied from -0.28 mm, for acrylic resin QC 20 subject to conventional polymerization, to 0.20 mm for acrylic resin QC 20 polymerized by microwave energy. The results obtained for the changes in the placement of artificial teeth did not show statistically significant differences among the groups either.

DISCUSSION

Specimens were prepared from a silicone matrix based on a toothless maxillary model, where a dentures was manufactured with wax with the prosthetic teeth. Then, the simulated prosthesis was duplicated by means of a silicone-based duplication material[12,14,18]. According to Keenan et al.[12], this standardization offers a simulated maxillary denture with minimized variations, among which there are effects in shape and size of the denture of the specimen and the polymerization changes. Three measurings were made in each specimen, always by the same trained operator, and the coefficient of variation of the repeated measurings did not exceed 0.20%.

Polat et al.[19] and Keenan et al.[12] stated that polimethyl-methacrylate acrylic resins showed dimensional changes during the processing. The causes of these dimensional changes are the polymer vs. monomer liquid ration, the type of resin and the condition of polymerization[20], which involves thermal expansion during heating, contraction during cooling, and contraction due to polymerization[12]. Taking this into account and because microwave polymerization offers advantages over the traditional method, it was considered necessary to assess four different acrylic resins and the impact of the microwave polymerization method on changes in the occlusal vertical dimension and on the horizontal placement of artificial teeth in dentures, when compared to the conventional polymerization method.

According to Mahler[21], changes in the occlusal vertical dimension are variables difficult to control during the polymerization process of dentures, perhaps because of the intrinsic features of acrylic resins[4]. Other factors may also contribute to the variation in occlusal vertical dimension, such as size, shape and thickness of prostheses, even if standardized, besides the presence of teeth[19,22]. According to Baemert et al.[23], in the last decades, different types of resins and polymerization methods have been introduced. In their research, Yeung et al.[24] verified that final prostheses may have an approximate contraction of 0.4% and, due to the complex shape of the prosthesis, such retraction may bring about distortions. Nevertheless, a combination of materials and processing techniques may reduce the distortion of the acrylic resin base to less than 0.2%[25]. In this study, changes regarding alterations in occlusal vertical dimension varied from -0.02% to 0.52%, yet, statistical tests did not identify significant differences. In millimeters, the averages of the changes in the vertical dimension of occlusion by the compression method of each experimental group were not in excess of

1.11 mm, and most of the groups were between -0.04 mm and 0.77 mm. These averages are close to the values reached by Basso[16] (0.9 mm), Dukes et al.[26] (0.76 mm), Strohaver[27] (0.63 mm) and are smaller than the values identified by Nogueira et al.[17] (1.16 mm).

Regarding movements of the artificial teeth during the process of placement and polymerization, the combination of many different factors produces dimensional changes, such as the intrinsic features of materials, contraction of polymerization, loss and sorption of water, polymerization timing and methods, influence of palate shape, duration of polishing procedure, effect of post-compression time, correct closure of muffles, and type of press. The delay in polymerization of the prosthesis after final compression may have an impact on the movement of artificial teeth, significantly affecting occlusal contacts[15]. Peytron[28] says that the muffle should to be left at rest for at least one hour before polymerization so that the resinous mass it left to penetrate into all the points of the mold and, thus, internal stress decreases during the initial stage once the muffle has been closed. In their research, Negreiros et al.[15], found significantly high dental movements in polymerized prostheses immediately after compression. Hence, horizontal changes, as measured between pre-determined points on an occlusal/incisal surface of the artificial teeth did not show statistically significant differences among them either. They varied from -0.2% to 0.08% and these results are similar to those quoted by Shibayama et al.[14], who, when comparing microwave with hot water polymerization, did not come across significant statistical differences.

Otherwise, dental positioning changes between pre and post polymerization periods of the assay groups varied from -0.16 to 0.21 mm. Such values are very small and are not clinically meaningful. Besides, they can be corrected by occlusal adjustment so that, when correctly adjusted, a greater balance of the dentures in the oral cavity is attained. This gives patients an adequate vertical dimension, less reabsorption of the residual ridge caused by the balance in the distribution of occlusal forces and, consequently, greater comfort for patients.

According to Anusavice[25] a slow cooling process after the processing of the muffles is recommended to avoid high residual stress, thus generating different thermal expansions between the cast mold and the support of the prosthesis. This stress is also one of the factors that greatly impacts on the dimensional change of the prosthesis and, as in this research the cooling period of the muffles took 24 hours[16], this probably contributed to avoiding significant dimensional changes between specimens, between the different brands of resins and the polymerization cycles that were used. Apart from all the factors related to the materials, methods and polymerization cycles mentioned above, another factor may have contributed to the absence of better dimensional features resulting from microwave polymerization vis a vis conventional polymerization: the difficulty in determining a relationship between ideal timing and power of the microwave device, which may have altered the intrinsic features of the acrylic resins[10].

When assessing the behavior of acrylic resins intended for conventional polymerization (Termo Clear, Clássico & QC20), that were also polymerized with microwave power, and the behavior of Onda-cryl resin, intended specifically for microwave polymerization and that also underwent conventional polymerization, results have not shown statistically significant differences as regards changes in the vertical dimension of occlusion and in the placement of teeth. Consistency in the results obtained for the polymerization cycles could be ascribed to compliance with laboratory procedures such as timing of inclusion and polymerization of the dentures. It should be pointed out that no mechanical strength studies were undertaken of the materials that were polymerized by mechanisms not recommended by manufacturers. Hence, it is suggested that scientific research be done to better assess the mechanical behavior of the different types of materials that were used and of the different laboratory techniques available for this research.

The overall assessment of the changes in the vertical dimension of occlusion and movement of artificial teeth in the polymerization method, did not bring about any statistically significant difference between specimens that underwent microwave polymerization and those subject to hot water polymerization. These results are consistent with several studies[4,12,22], and no significant dimensional changes between both techniques were reported. There was no difference either in the

behavior of the different commercial brands of acrylic resins that went through microwave polymerization.

Thus, it could be suggested that for the acrylic resins that were assessed, both polymerization methods –conventional and microwave– may be used without significant clinical changes as regards the vertical occlusion dimension and the movement of artificial teeth.

CONCLUSION

Based on the findings, the following conclusions were reached:

1. The vertical occlusion dimension was not affected by the change in the polymerization cycles of both groups;
2. The placement of the artificial teeth in dentures was not affected by the change in the polymerization cycles.

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