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Dental displacement in complete dentures influenced by different flask types and polymerization cycles

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This study evaluated the dental displacement in dentures included in different flasks and processed by the Australian cycle modified or by microwave. Metal pins were placed on the teeth as reference for measurements: a) Incisal edge of maxillary and mandibular central incisors, buccal cusp of maxillary and mandibular vestibular first premolars, and mesiobuccal maxillary and mandibular cusps of second molars; b) Incisor to incisor, premolar to premolar and molar to molar; c) Left incisor to left molar and right incisor to right molar, and d) Vertical. Dentures were divided according to flasks (n=10): G1- Metal; G2- HH bimaxillary metal; G3- Microwaves; G4- HH bimaxillary microwaves. For G1 and G2, polymerization at 65ºC/30 min, flame quenched for 30 min, heating at 65ºC/30 min, boiling water for 1 h. For G3 and G4, microwave (20 min/140 W and 5 min/560 W). Comparator microscope with digital camera and analytical unit assessed the measurements before and after denture polymerization. The final distance was made subtracting the distance before the denture processing from the distance of the dental displacement after processing. The value of the difference was submitted to 2-way ANOVA, considering the flask type and denture type. Maxillary denture showed greater displacement when compared to mandibular denture. Flask types and interaction with denture types showed similar difference between before and after polymerization. In conclusion, displacement promoted by flask types in dentures cured by polymerization cycles promoted similar effect on the distance between teeth. Greater value for distance between teeth occurred for maxillary denture.

Key Words: dental displacement, complete denture, flask type, polymerization cycle.

Introduction

Acrylic resins based on poly methyl methacrylate have been used in large scale and remain today as material to produce complete dentures due to easiness of handling, acceptable mechanical properties and low cost. However, the polymerization shrinkage is a problem inherent to acrylic resins and considered as an inevitable occurrence during the processing of the dentures. As clinical consequence, the complete denture bases are subject to same characteristics of the dimensional changes that occur in this polymeric material. Nevertheless, the complete dentures are excellent indications for edentulous patients, since they present adequate stability for specific oral conditions, favorable aesthetics, and satisfactory masticatory function (1).

For many years, the importance of maintaining the occlusal balance of the masticatory system has been emphasized for the successful of the oral rehabilitation with complete dentures (2). The denture disharmony may lead to misfit, over extension, lack of aesthetics, and failure to reestablish the occlusal equilibration of the vertical dimension, compromising the desired function as consequence of the negative occlusal interferences. Moreover, during the acrylic resin polymerization shrinkage the artificial teeth can displace causing occlusal interference, traumatic occlusion, discomfort, and irregular stress distribution on the soft tissue impairing the oral function of the denture as a whole (3).

There are also other factors that can cause dental displacement, as base thickness and curing cycles (4), acrylic resin stress relaxation (5), flask closure system (6), flask closure and flask cooling (7), and flask closure and post-pressing time (8). Nonetheless, some studies have stated that the water absorbed by the acrylic resin could minimize the negative effect of dental displacement (1,9,10).

Aiming to decrease the dental displacement level, mono and bi-maxillary metal flasks for complete denture was developed to relate the maxillary and mandibular teeth in occlusion during the denture bases processing (11). Plastic flask for microwaves irradiation was developed similarly to metal flask for double dentures inclusion, and both denture bases were polymerized simultaneously with the maxillary and mandibular teeth in occlusion (12). A study alleged that this method promotes satisfactory occlusal harmony, minimizing the errors in the reestablishment of the vertical dimension of occlusion (13).

Studies have shown that the bi-maxillary flask promotes reduction of the vertical dimension (14), lesser teeth displacement (15), and no change in porosity, surface roughness and Knoop hardness of the acrylic resins (16) when compared to conventional flask. Additionally, the inclusion of two complete dentures in the same flask promotes 20% of material reduction for each denture (13).

The literature is still lacking of studies related to acrylic resin polymerization shrinkage in relation to complete denture inclusion methods. The aim of this study was evaluate the dental displacement in maxillary and mandibular conventional complete dentures processed in different flasks: traditional metal, HH bi-maxillary metal, traditional microwave or HH bi-maxillary microwave. The tested hypotheses were that the dental distance promoted by the artificial teeth displacement would not influenced by 1- Flask type; 2- Polymerization cycle; and 3- Denture type (maxillary and mandibular).

Material and methods

The conventional maxillary and mandibular complete denture bases were processed with conventional or microwaved acrylic resins (Classico Dental Products, Sao Paulo, SP, Brazil). The properly mixed acrylic resin was placed into the cavity of the gypsum cast included in the metal flasks (Conventional - Safrani Metallurgical Products, Sao Caetano do Sul, SP, Brazil and HH bimaxillary - Bethil, Campinas, SP, Brazil) or in plastic flasks (Conventional - Classico and HH bimaxillary - Classico). The denture bases were processed in hot water bath adapted from the Australian cycle or by microwave irradiation.

Maxillary and mandibular models were processed with dental stone (Type III Herodent Soli-Rock; Vigodent, Rio de Janeiro, RJ, Brazil), manually mixed in a plastic bowl with metal spatula in the water-powder ratio determined by the manufacturer. The pre-weighed powder was gradually added to the measured water, and incorporated by 1 min until a smooth mix was obtained. The mounting of the teeth (Trilux EuroVipi 036/L7/M4; VIPI, Pirassununga, SP, Brazil) was carried out in semi-adjustable articulator (Bio-Art Dental Products; Sao Carlos, SP, Brazil). A silicone matrix (Zetalabor; Zhermack, Rovigo, Italy) was obtained from the dental arch of each first maxillary or mandibular denture manufactured. After, these matrices were used to standardize the teeth assemblies in the manufacturing of the other dentures. With this procedure, 40 denture pairs were processed.

Metal pins were placed on the waxed denture teeth as reference points for measurements before and after dentures processing. The pins were fixed with cyanoacrylate-based glue (Super Bonder; Loctite Henkel, Sao Paulo, SP, Brazil) in predetermined tooth sites of the maxillary and mandibular dentures: Incisal edge center of the central incisors (I), lingual cusp of the first premolars (P), and mesiolingual cusp of the molars (M).

The dental distance measurements were made before (baseline) and after denture processing using a linear comparator microscope (Walter-UHL-VMM-100-BT; Germany), equipped with digital camera (KC-512NT; Kodo BR Electronics, Sao Paulo, SP, Brazil), and analytical unit (QC 220-HH Quadra-Check 200; Metronics, Bedford, New Hampshire, USA) with 1.0 μm accuracy and 120x magnification. The denture was positioned in the lecture platform of the microscope, and the dental distances measured on the following planes: 1) Horizontal - X axis: Incisor to incisor (I-I), premolar to premolar (P-P), molar to molar (M-M), left incisor to left molar (lI-lM), and right incisor to right molar (rI-rM), and 2) Vertical distances - Z axis: I-I; P-P, M-M, lI-lM, rI-rM. The final distance between teeth (FTD) was considered as the difference between the values obtained after denture processing (ADP) and before processing (BDP), using the equation FTD = ADP-BDP.

Maxillary and mandibular dentures sets were randomly divided into 4 groups according to flask type (n=10): G1 - Conventional metal; G2 - HH bi-maxillary metal (teeth in occlusion); G3 - Conventional microwave; and G4 - HH bi-maxillary microwave (teeth in occlusion). The acrylic resin packing in the cavity mold for the conventional and HH bi-maxillary metal flasks or conventional and HH bi-maxillary microwave flasks was according to traditional techniques showed in literature, aiming to decrease the methodological discrepancies between the current study and previous works (10,13).

Acrylic resins were proportioned and manipulated according to manufacturer's instructions using the polymer-monomer ratio of 3:1, by volume. The conventional acrylic resin (Classico) was packed into the metal flasks in the doughlike state, the flask assembly was placed into a press and the load incrementally applied until the flask was completely closed. After, the flask was open, the polyethylene sheet and the resin excess (flash) removed. After the definitive closure, the flask was placed in a flask carrier, and the denture base processed by the Australian cycle adapted. In this cycle, the metal flask was immersed in water bath at room temperature and heated at 65ºC for 30 min. The heating was interrupted for 30 min, submitted again to heating at 65ºC for 30 min and at 100ºC for 1 h. The flask was cooled in the own polymerization water for 8 h. At this time, the flask was removed from the water bath, and the denture deflasked, finished, and polished.

Microwaved acrylic resin (Onda Cryl; Classico) was packed similarly to conventional resin in plastic flask, except that the final flask closure was made by means of screws. The polymerization cycle was processed in microwave oven (BSH Continental AW-42; Manaus, AM, Brazil) as recommended by the manufacturer (20 min at 140 W and 5 min at 560 W potency). After cooled in bench at room temperature by 30 min, the flask was open, and the denture deflasked, finished, and polished.

The sample size for each maxillary and mandibular denture set was based on literature (6,10), and it would be enough to represent the sampling of the universe in this comparative method. The sample size of each set (n=10) was proposed to achieve the effect according to difference of two means divided by the standard deviation from the data (Cohen effect size). Tukey's test at significance level of 0.05% was proposed to achieve the effects of other independent variables and interactions partialled out (partial eta squared measure). Thus, the 2-way ANOVA was the recommended test for this situation, since the dental displacement varying according to flask type and the denture type. The p-paired statistical test compared the final values of the distances between teeth at same set.

Results

Table 1 shows means and standard deviation from the difference between the dental displacements occurred before and after denture polymerization in relation to flask and denture types. There was statistically significant difference between the maxillary and mandibular dentures in relation to dental distance values occurred by the difference between before and after the denture processing.

Table 1. Means and standard deviation of the values resulting from the difference of the dental displacement occurred before and after denture polymerization in relation to flask and denture types.

	Flask type							
	Conventional metal		HH metal		Conventional microwave		HH microwave	
Tooth	Maxillary	Mandibular	Maxillary	Mandibular	Maxillary	Mandibular	Maxillary	Mandibular
I-I	0.094 ± 0.16	0.007 ± 0.36	-0.019 ± 0.26	0.034 ±0.14	0.154 ± 0.13	-0.002 ±0.08	0.125 ± 0.22	0.068 ± 0.319
P-P	0.275 ± 0.20	0.141 ± 0,17	0.283 ± 0.17	0.108 ±0.16	0.449 ± 0.22	0.138 ± 0.18	0.372 ± 0.37	0.118 ± 0.312
M-M	0.439 ± 0.20	0.168 ± 0.16	0.456 ± 0.22	0.077 ± 0.29	0.438 ± 0.20	0.169 ±0.25	0.518 ± 0.16	0.234 ± 0.180
Id-Md	-0.212 ± 0.67	0.46 ± 0.55	-0.565 ± 0.82	0.348 ± 0.50	-0.279 ± 1.05	0.384 ± 0.42	0.277 ± 0.90	0.303 ± 0.503
Ie-Me	0.661 ± 0.53	-0.087 ± 0.53	1.128 ± 0.60	-0.088 ± 0.7	0.936 ±1.14	0.017 ± 0.86	0.048 ±1.05	0.137 ± 0.472

Table 2 shows the effect of the flask type, denture type and their interactions over the difference of the dental displacements occurred before and after dentures polymerization. The flask type did not affected the dental displacement, as well as the interaction between flask type and denture type ($p>0.05$, 2-way ANOVA). There was statistically significant difference between denture types in relation to each evaluated distance ($p<0.05$, 2-way ANOVA), except for I-I distance ($p=0.395$).

Table 2. Two-way ANOVA for flask type, denture type and their interactions for the values resulting from the difference of the dental displacements occurred before and after denture polymerization.

	Dependent variable	Sum of Squares	*df*	Mean Square	F value	*P**
Flask type	I-I	0.693	3	0.231	1.027	0.386
	P-P	0.230	3	0.077	0.474	0.701
	M-M	0.225	3	0.075	0.617	0.606
	Id-Md	1.582	3	0.527	0.940	0.426
	Ie-Me	1.672	3	0.557	0.901	0.445
Denture type	I-I	0.165	1	0.165	0.734	0.395
	P-P	1.176	1	1.176	7.293	0.009
	M-M	2.927	1	2.927	24.042	0.000
	Id-Md	12.704	1	12.704	22.629	0.000
	Ie-Me	6.634	1	6.634	10.725	0.002
Flask type x	I-I	0.805	3	0.268	1.194	0.318
denture type	P-P	0.099	3	0.033	0.205	0.893
	M-M	0.130	3	0.043	0.357	0.784
	Id-Md	0.234	3	0.078	0.139	0.936
	Ie-Me	3.505	3	1.168	1.889	0.139
Total	I-I	21.741	80	-	-	-
	P-P	32.179	80	-	-	-
	M-M	37.211	80	-	-	-
	Id-Md	55.098	80	-	-	-
	Ie-Me	61.739	80	-	-	-

Figure 1 shows the means and standard deviation for the difference between the dental displacements occurred before and after polymerization according to evaluated distance and denture type (maxillary or mandibular). The maxillary denture showed greater dental displacement when compared to mandibular denture for all evaluated distances (P-P: p=0.009; M-M: p=0.0001; Id-Md: p=0.0001; Ie-Me: p=0.002; 2-way-ANOVA), except for the I-I distance (p>0.05, 2-way ANOVA).

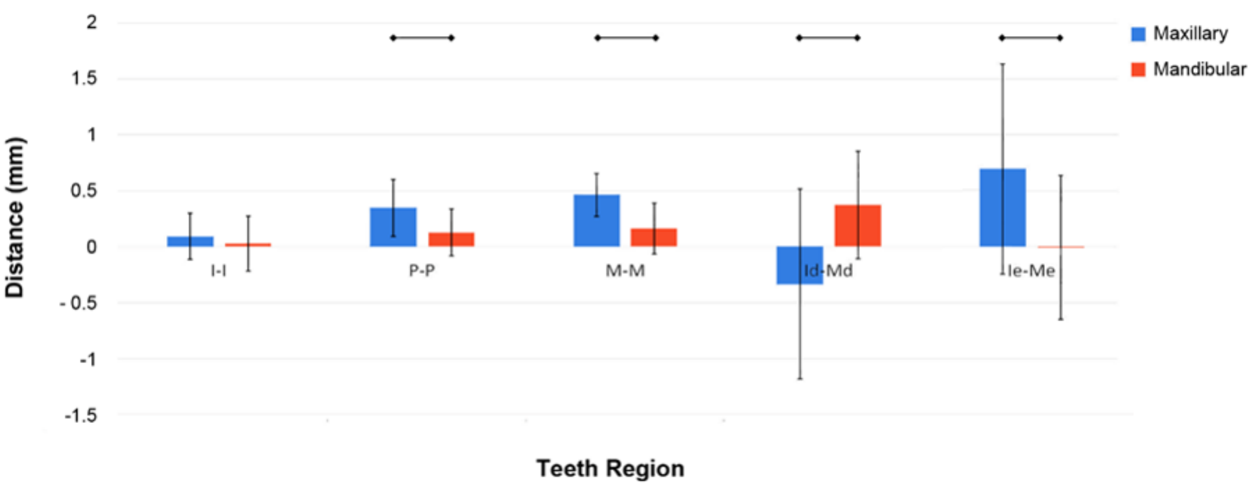

Figure 1. Dental displacement (mm) after polymerization for denture type (maxillary or mandibular) in relation to before polymerization. Groups connected by horizontal line show statistical difference between dentures in each region.

Discussion

This study verified the dental distances in maxillary and mandibular complete dentures influenced by different flasks submitted to different polymerization cycles. Previous studies showed that the closure type and cooling method of flasks (7), as well as the deflasking delay time did not influence the dental displacement of maxillary dentures (17). Table 2 shows that the flask type and the interaction between flask type and denture type did not negatively affected the dental displacement ($p>0.05$, 2-way ANOVA).

The first hypothesis tested that the flask type would not influence the dental displacement was accepted. This result is in agreement with studies showing that flask type is not a factor that would can influence significantly the dental displacement in mandibular fixed implant-supported complete dentures (1), maxillary dentures (7), and implant-supported prosthesis processed by microwave flask (10).

The study also showed that the difference in the horizontal and antero-posterior dental distances were not statistically significant when the dentures were polymerized in the metal flasks or plastic flasks for microwave energy. Thus, the second hypothesis that different polymerization cycles would not influence the dental distance was accepted. This result is in agreement with studies showed in the literature (1,10,18-20).

It is probable that in further studies with small methodological differences in the dentures processing, as inclusion method, stone cast type, denture position inside flask, flask type, polymerization cycle, flask cooling method, denture deflasking and polishing method can lead to different levels of dental displacements when compared to those obtained in the present investigation.

This disagreement related to dental displacement also already occurred in previous works (1,6,7,17,18,20). Moreover, some divergences were shown in the dental displacement for maxillary dentures when different metal flask types were used (21), fact that would also explain the effect caused on the dental position change by different denture inclusion methods.

These results have also shown that whatever the flask type or polymerization cycle used in the study, the findings were different and statistically significant between the maxillary and mandibular dentures in relation to dental distance (Table 1). Thus, the third hypothesis that denture types would not influence the distance between teeth was not accepted. The supposition alleged for this result would be the fact that maxillary or mandibular denture bases were differently influenced in relation to stability of the artificial teeth after denture processing due to different thermal shrinkage levels occurred during the cooling of different flask types and after denture deflasking (7,17).

The denture base thickness is a significant factor for the magnitude of the linear shrinkage that occurs during denture processing (22). Changes in the linear dimension occur according to acrylic resin thickness submitted to polymerization cycle, and the position of the denture inside the flask is another factor that differently interfere on the dental displacement (23). It has been also claimed that the molar inclination in maxillary denture was greater for thinner base (1.25 mm) when compared to thicker base (3.75 mm), there were significant change in dental displacement between thick and thin denture bases while an increase in the molar-to-molar distance was shown in both the thin and thick dentures (23).

However, for many years the dental literature showed that the magnitude of dental displacement would be larger in thick denture bases. Previous studies showed that two layers of wax plate (1 mm each) were sufficient to standardize the denture base thickness across the groups (25), as well as there were significant changes in dental movement between thick and thin denture bases (24). In the current study, the denture bases thickness was standardized at 2 mm. This base thickness probably led to similar levels of acrylic resin polymerization shrinkage, promoting smaller difference between the levels of dental displacement occurred on the denture sets.

Moreover, maxillary and mandibular dentures showed greater distances at posterior teeth, especially for the molars when the horizontal and anteroposterior distances were considered (Figure 1). Despite the shape of the maxillary alveolar arch to favor the stress distribution of the denture base when compared to the mandibular alveolar arch, the palate anatomy allows greater acrylic resin shrinkage mainly at the posterior border, compromising the marginal sealing at this region (6). On the other hand, the smaller displacement at I-I distance showed in the current study was probably due to interproximal contact type of the incisor teeth. This fact would be related to smaller acrylic resin amount at anterior region, and consequent lesser polymerization shrinkage level when compared to palatal region of the maxillary denture or free ends of the mandibular denture (26).

The different denture base regions promoted different values for the distances P-P, M-M, rI-rM, and lI-lM (Figure 1). Despite the similar behavior between before and after polymerization in relation to dental displacement, the mandibular denture showed distances with values less changed than the maxillary denture. The supposition for this finding would be that the mandibular denture shows similar distortion at the two free ends, fact that does not occur in the maxillary denture with different stress concentration in each region due to palate shape; however, the base retention and stability levels are considered better for maxillary denture. Moreover, the dimensionally more stable areas in the maxillary denture are the regions of canines and the most unstable is the posterior palate region (27). Although different levels of dental movement can be expected depending on the processing denture methods, the total clinical significance of these differences is still unknown (28,29).

However, other fact did not evident in the current study was that the vertical teeth displacement would be related to occlusal vertical dimension values, and probably also in function of the polymerization methods. In addition, two polymerization cycles in water bath for conventional acrylic resin resulted in the best occlusal vertical dimension for complete-arch prosthesis when compared to two microwave curing cycles (30), highlighting the hot water bath curing method of conventional acrylic resins for denture bases.

The current study became important when investigated the changes in the dental distances influenced by flask types in dentures cured by different polymerization cycles. The results showed that the posterior portion of the maxillary and mandibular alveolar arches is an anatomical region that can lead to the greatest dental displacement, changing the dental distance in both denture base types.

However, the study did not consider the different forms of the palate vault in maxillary denture that can influence on the acrylic resin polymerization shrinkage levels, mainly on the posterior region and its consequent alteration on the teeth displacement values after denture base processing. In relation to mandibular dentures, the length of the alveolar ridges and the distance between them in the posterior region can also interfere in the contraction of polymerization of the acrylic resin and on the different levels of dental displacement. These factors did not evaluated can be considered as limitations of the study. In conclusion, dental displacement promoted by different flask types in dentures cured by different polymerization cycles promoted similar effect on the distance alteration between teeth. Greater value for distance change between teeth occurred for maxillary denture.

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Resumo

O objetivo neste estudo foi avaliar o deslocamento dental em próteses totais incluídas em diferentes tipos de muflas e polimerizadas pelo ciclo australiano ou por micro ondas. Pinos metálicos foram colocados nos dentes como pontos de referência para as medidas: a) Borda incisal dos incisivos centrais maxilares e mandibulares, cúspide vestibular dos primeiros pré molares maxilares e mandibulares e cúspides mésiovestibulares dos segundos molares maxilares e mandibulares; b) Distâncias látero-laterais incisivo a incisivo, pré-molar a pré-molar e molar a molar; c) Distâncias horizontais anteroposterior incisivo esquerdo a molar esquerdo e incisivo direito a molar direito, e d) Vertical. As próteses foram separadas de acordo com o tipo de mufla (n=20): G1- Metálica; G2-HH bi-maxilar metálica; G3- Micro-ondas; G4- HH bi-maxilar micro ondas. Ciclo de polimerização para G1 e G2, água a 65°C por 30 minutos, aquecimento interrompido por 30 minutos, reaquecimento a 65°C por 30 minutos, seguido de água fervente por 1 hora. Para G3 e G4, micro ondas (20 minutos a 140 W e 5 minutos a 560 W). As medidas foram avaliadas com microscópio comparador linear. A distância final entre os dentes foi obtida subtraindo o valor da distância antes do processamento da prótese do valor da distância resultante do deslocamento dentário após o processamento. A diferença obtida entre essas distâncias foi submetida à ANOVA de 2 fatores, considerando como variáveis tipo de mufla e tipo de prótese. A prótese maxilar apresentou maior deslocamento dental quando comparada à mandibular. Os tipos de muflas e a interação com os tipos de próteses mostraram movimentos dentais similares antes e depois da polimerização. Em conclusão, o deslocamento dental promovido por diferentes tipos de frascos em próteses curadas por diferentes ciclos de polimerização promoveu efeito semelhante na alteração da distância entre os dentes. Maior valor para a mudança de distância entre os dentes ocorreu na prótese maxilar.

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