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Estudo do deslocamento dental linear em próteses totais processadas em diferentes ciclos de polimerização e tempos pós-prensagem

Tese apresentada à Faculdade de Odontologia de Piracicaba, Universidade Estadual de Campinas, para a obtenção do Título de Doutor em Clínica Odontológica – Área Prótese Dental.

Orientador: Prof. Dr. Rafael Leonardo Xediek Consani

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RESUMO

Este trabalho verificou a movimentação de dentes em próteses totais confeccionadas a partir de diferentes ciclos de polimerização e tempos pós-prensagem. Foram confeccionadas 40 próteses totais superiores com as resinas acrílicas Clássico, QC-20 e Onda-Cryl, as quais foram distribuídas por sorteio em 8 grupos (n=5) de acordo com os ciclos de polimerização (longo em banho de água aquecida (grupo-controle), curto em água em ebulição e por energia de microondas) e tempos pós-prensagem (imediato e 6 horas). A montagem dos dentes foi realizada em articulador semi-ajustável, tendo como referência um modelo inferior dentado. Pinos referenciais metálicos foram posicionados na borda incisal dos incisivos centrais, na cúspide vestibular dos primeiros pré-molares e cúspide mésio-vestibular dos segundos molares. As distâncias transversais PMD-PME (pré-molar direito a pré-molar esquerdo) e MD-ME (molar direito a molar esquerdo) e ântero-posteriores ID-MD (incisivo direito a molar direito) e IE-ME (incisivo esquerdo e molar esquerdo) foram mensuradas antes e após o processamento, utilizando microscópio comparador (Olympus Optical Co., Tokyo, Japan), com precisão de 0,0005mm. As resinas acrílicas Clássico e QC-20 foram proporcionadas e manipuladas de acordo com as instruções dos fabricantes e submetidas aos ciclos de polimerização em água a 74ºC por 9 horas e em água em ebulição por 20 minutos, respectivamente. A resina Onda-Cryl foi submetida à polimerização por energia de microondas no ciclo 3 minutos a 35%, 4 minutos a 0% e 3 minutos a 65% da potência máxima do forno de microondas. Os dados coletados foram submetidos à análise de variância e as médias foram comparadas pelo teste de Tukey em nível de 5% de significância. Todas as distâncias mostraram movimentação dental; entretanto, esta não foi estatisticamente significante (5%) antes e após a polimerização para todos os ciclos de polimerização analisados. O ciclo de polimerização por microondas foi comparável estatisticamente ao ciclo convencional em banho de água aquecida (grupo controle) em relação à magnitude da movimentação dental. O tempo pós-prensagem 6 horas não mostrou vantagens em reduzir a magnitude do deslocamento dental em relação à polimerização imediata, na maioria das distâncias avaliadas. Concluiu-se que as alterações não foram similares, mostrando influência das resinas, tempo pós-prensagem e distância entre dentes.

Palavras – chave: Prótese total; Movimentação dental; Ciclo de polimerização; Prensagem.

ABSTRACT

This study verified the tooth movement in maxillary complete dentures submitted to different polymerization cycles and post-pressing times. Forty maxillary complete dentures fabricated with Classico, QC-20, and Onda-Cryl acrylic resins, were randomly assigned into 8 groups (n=5) according to the polymerization cycles (long cycle in water bath (control-group), fast cycle in boiling water, and microwave cycle) and the post-pressing time (immediate and after 6 hours). The wax pattern was made using a semi-adjustable articulator having a mandibular dentate cast as a reference. Metallic referential pins were placed on the incisal border of the central incisors, vestibular cusp of the first premolars, and the mesio-vestibular cusp of the second molars. The PMD-PME (right premolar to left premolar), MD-ME (right molar to left molar) transversal distances and RI-RM (right incisor to right molar) and LI-LM (left incisor to left molar) anteroposterior distances were measured before and after the complete dentures processing with a linear optical microscope (Olympus Optical Co., Tokyo, Japan) with an accuracy of 0.0005mm. All acrylic resins were proportioned and manipulated following the manufacturer's directions. Classico and QC-20 acrylic resins were submitted to the conventional water bath curing at 74ºC for 9 hours or to boiling water curing for 20 minutes respectively. Onda-Cryl acrylic resin was processed by microwave energy cycle for 3 minutes at 35%, 4 minutes at 0%, and 3 minutes at 65% power of the microwave oven. Collected data were submitted to the ANOVA and Tukey test at 5% of significance. All distances showed tooth movement; however, that was not statistically significant (5%) before and after processing for all polymerization cycles analyzed. The microwave polymerization cycle was statisticaly comparable with the conventional one in water bath (control group) considering the magnitude of tooth movement. The 6-hour post-pressing had no advantage in reducing the magnitude of tooth movement in relation to the immediate polymerization for most of the distances evaluated. It was concluded that the changes were not similar being influenced by the polymerization cycles, post-pressing time, and distance among teeth.

Key Words: Complete denture, Artificial tooth, Tooth movement, Post-pressing time.

SUMÁRIO

1-INTRODUÇÃO

Durante as últimas décadas, a Odontologia Restauradora tem procurado reduzir as dificuldades funcionais e melhorar a estética dos pacientes desdentados totais. Esses pacientes geralmente apresentam prejuízos no seu dia-a-dia em relação à qualidade de vida. Após a perda dos dentes naturais, ocorrem consideráveis mudanças em relação aos hábitos alimentares, ao estado geral de saúde, ao bem-estar psicológico e físico e à satisfação com a própria vida (Koshino *et al*., 2006).

O advento dos implantes osseointegrados representou, sem dúvida alguma, grande avanço nas técnicas de reabilitação bucal e uma nova esperança para os pacientes totalmente desdentados. A princípio seria fácil imaginar que as próteses totais não teriam mais utilização como opção de tratamento na Odontologia e a solução seria creditada exclusivamente aos implantes. Contraditoriamente, fica cada vez mais evidente a importância do conhecimento sobre a reabilitação com próteses totais, considerando que as próteses do tipo "Protocolo de Branemark" exigem a utilização de todos os princípios empregados na reabilitação com próteses totais convencionais (Spiekermann, 1995).

Infelizmente, muitos pacientes não podem se submeter à terapia com implantes seja por limitações de ordem financeira, anatômica e de saúde sistêmica. Funcionalmente, os usuários de próteses totais convencionais necessitam de reeducação alimentar. Bradbury *et al*. (2006) relataram que muitos pacientes passam a ter deficiência nutricional importante, e precisam ser orientados na dieta para a sua nova condição mastigatória. Psicologicamente, a condução do tratamento protético deve ser bastante cuidadosa, procurando-se criar bom relacionamento profissional-paciente no sentido de evitar frustrações e aumentar as chances de sucesso ao final da terapia (Carlsson, 2006). Do ponto de vista da confecção da prótese, muitas variáveis podem influenciar o resultado final, sendo imprescindível o respeito a todas as etapas clínicas e laboratoriais (Turano & Turano, 2002).

Dessa maneira ainda há grande demanda por próteses totais, sendo a resina acrílica o material de eleição (Kimpara & Muench, 1996). Esse material tem grande aplicabilidade na clínica odontológica e continua sendo alvo de estudos científicos no sentido de se compreender suas verdadeiras características (Anusavice, 2003; Craig & Powers, 2004). Freqüentemente durante o processamento das próteses totais, alterações dimensionais na base podem levar à falta de adaptação e à conseqüente perda da retenção, e o deslocamento dos dentes artificiais pode desarmonizar o esquema oclusal e alterar a dimensão vertical de oclusão (Parvizi *et al*., 2004). As mudanças na dimensão vertical de oclusão em prótese total podem estar relacionadas tanto às características intrínsecas dos materiais como às suas técnicas de utilização.

A confecção de uma prótese total compreende um complexo conjunto de procedimentos laboratoriais que pode gerar, em maior ou menor grau, alterações dimensionais no final do processamento. Em muitas situações é bastante difícil identificar qual a fase laboratorial responsável pelas alterações, dada a grande quantidade de variáveis que influencia o processo. Qualidade e quantidade de monômero residual (Skinner, 1951; Consani *et al*., 2002), excesso de resina dentro do molde (Grunewald *et al*., 1952), contração térmica e de polimerização da resina (Woelfell, 1977), método de inclusão proposto (Mainieri *et al*., 1980, Nogueira *et al*., 1999), diferença entre o coeficiente de expansão térmica linear da resina e do gesso (Wolfaardt *et al*., 1986; Takamata & Sectos, 1989), forma geométrica do palato (Abuzar *et al*., 1995; Arioli-Filho *et al*., 1999), métodos de polimerização e resfriamento (Wong *et at*., 1999; Teraoka & Takahashi, 2000; Kimoto *et al*., 2005), sorção de água (Braun *et al*., 2000), expansão do revestimento (Atkinson & Grant, 1962) precisam ser considerados como fatores importantes durante a confecção da prótese e a utilização pelo paciente.

Um aspecto particular que pode influenciar positivamente no deslocamento dos dentes artificiais é a demora para polimerização da prótese após a fase da prensagem final. Provavelmente, esse fator pode estar relacionado com a maior uniformidade na liberação de tensões dentro da massa da resina, o que contribuiu para menor distorção da base da prótese (Consani *et al*., 2004). Entretanto, trabalhos científicos divergiram em apontar vantagens para a polimerização realizada após 12 ou 24 horas da prensagem final (Consani *et al.,* 2001), ao passo que outros estudos não comprovaram essa relação (Kimpara & Muench, 1996). Contudo, aguardar um longo tempo para polimerizar a prótese pode ser um procedimento de difícil aplicação na rotina dos laboratórios. Possivelmente, a busca por um tempo pós-prensagem realmente efetivo em reduzir alterações dimensionais e que apresente aplicabilidade nos laboratórios de prótese seria um fato importante.

Nas últimas décadas, a partir da publicação de Nishi (1968), iniciou-se o uso da energia de microondas para polimerização da resina acrílica nos procedimentos laboratoriais, sendo ainda, esse método, o alvo de muitas pesquisas na atualidade. Alguns trabalhos mostraram vantagens de redução do tempo de polimerização (Hayden, 1986), limpeza e higiene dos procedimentos (Sanders *et al*., 1987), e até maior adaptação da base da prótese no modelo de gesso (Takamata *et al.,* 1989) para o processamento em forno de microondas. Relevantes estudos recentes focaram o efeito da energia de microondas na desinfecção de próteses (Consani *et al*., 2007; Seo *et al.*, 2007), bem como a influência desse método na porosidade e na espessura da resina acrílica (Pero *et al*., 2007).

A comparação da eficiência entre os diversos ciclos de polimerização em relação a potenciais alterações dimensionais continua sendo bastante investigada na literatura (Blagojevic & Murphy, 1999; Keenan *et al*., 2003). Goiato *et al*., (2000) verificaram que a polimerização convencional (ciclo longo em banho de água 74°C por 9 horas) ocasionou maior alteração dimensional que a polimerização por microondas. Entretanto, Barbosa *et al*. (2002) não observaram diferença estatística significativa na abertura do pino guia incisal entre próteses totais polimerizadas no ciclo convencional ou em 3 diferentes ciclos de polimerização por microondas. Resinas acrílicas convencionais têm sido polimerizadas por energia de microondas, obtendo-se comportamento dimensional similar ao das resinas especificamente designadas para esse método (Baroncini Neto *et al*., 1998; Braun *et al*., 2000). Já, outro estudo verificou que as resinas convencionais podiam apresentar maior porosidade que as de microondas (Yannikakis *et al.,* 2002).

Até o momento, nenhuma investigação científica procurou comparar o efeito do método de polimerização por microondas (utilizando resinas designadas para microondas e resinas convencionais) e os ciclos clássicos em banho de água aquecida em relação ao deslocamento dental linear em diferentes tempos pós-prensagem. A busca por um método de polimerização prático, rápido e que ofereça estabilidade dimensional após o processamento parece ser um estudo muito interessante.

Portanto, o presente trabalho tem o objetivo de verificar e comparar o efeito de ciclos de polimerização convencional (longo e curto em banho de água) e por energia de microondas em associação com o tempo pós-prensagem (imediato e 6 horas), na movimentação linear de dentes em prótese total superior.

2- CAPÍTULOS

Artigo científico intitulado "Dimensional stability of distances between two teeth in maxillary complete dentures comparing microwave polymerization and the conventional cycles" submetido à apreciação da Revista *Journal of Prosthodontics.*

Dimensional stability of distances between teeth in maxillary complete dentures comparing microwave polymerization and the conventional cycles

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Abstract

Purpose. Microwave polymerization is a clean, fast, and practical processing method of dentures. The relation between this method and the occurrence of tooth movement remain unsolved. This study investigated the tooth movement of complete dentures processed by microwave activation and conventional processing method in water bath.

Materials and methods. Twenty maxillary complete dentures were fabricated and randomly assigned according to 4 groups (n=5): Group I: Classico conventional heat-curing acrylic resin processed by microwave polymerization for 3 minutes at 35%, 4 minutes at 0%, and 3 minutes at 65% power of the oven; Group II: Classico resin processed in water bath at 74°C for 9 hours (control-group); Group III: QC-20 fast heat-curing acrylic resin processed in boiling water for 20 minutes; Group IV: Onda-Cryl microwave acrylic resin processed at the same conditions of Group 1. Metallic referential pins were placed on the incisal border of the central incisors (RI and LI), vestibular cusp of the first premolars (RP and LP), and the mesio-vestibular cusp of the second molars (RM and LM). The RP-LP and RM-LM transversal distances, and RI-RM and LI-LM anteroposterior distances were measured before and after the complete dentures processing with a linear optical microscope (Olympus Optical Co., Tokyo, Japan) with an accuracy of 0.0005mm. Collected data were submitted to ANOVA and Tukey test at 5% of significance.

Results. Inside each group, dentures showed some tooth movement but without statistical difference before and after the polymerization. Only for the distance RP-LP there was significant tooth movement after polymerization, and Group 1 presented the greatest magnitude of tooth movement.

Conclusion. Dentures processed by microwave energy presented similar performance than they submitted to conventional cycles in water bath for most of distances evaluated. The study suggests that

conventional heat-curing acrylic resins may be used for microwave polymerization without great dimensional changes.

Index Words: Acrylic resin, Artificial tooth, Tooth Movement.

Introduction

It is clinically important that dentures have accurate occlusal contacts to guarantee normal function. Tooth displacement study has been important in seeking a more stable occlusal pattern, retention, and functional quality of complete dentures (1) (McCartney, 1984). Later studies (2,3) (Peyton, 1950; Firtell et al., 1981) showed that typically, the magnitude of dimensional changes is not too large, and mean changes of -0.1% to -0.4% have been reported as having no significant influence on the serviceability of dentures (4) (Mowery et al., 1958).

The performance of different polymerization cycles, including the microwave technique, was analyzed in some investigations considering the processing alterations (5,6) (Blagojevic & Murphy, 1999; Keenan et al., 2003). After the Nishi's publication in 1968 (7), the microwave processing method has been appointed as fast (8) (Hayden, 1986), clean (9) (Sanders et al., 1987), and that promotes an ideal fitting of the denture to the cast (10) (Takamata et al., 1989). The use of the conventional heat-curing acrylic resins instead of the microwave ones and that influence on the dimensional changes also remain unresolved (11,12) (Braun et al., 2000; Yannikakis et al., 2002). It'd be necessary to analyze the magnitude of the linear tooth movement in complete dentures submitted to conventional and microwave polymerization cycles using different resin types.

Materials and Methods

A silicone mold (Elite Double; Zhermack, Rovigo, Italy) was formed from a metal master edentulous maxillary die without irregularities in the alveolar ridge walls. Twenty identical casts were poured from this mold with artificial type III dental stone (Herodent Soli-Hock; Vigodent, RJ, Brazil) in a ratio of 30 ml water to 100g powder.

A uniform denture base was made with a 2mm thick plate wax (Epoxiglass; Epoxiglass Chemical Products, Diadema, SP, Brazil) measured with a caliper. The height of the occlusion wax rim was 20mm in the buccal sulcus of the cast and 10mm in the second molar area. The maxillary stone cast was mounted in a Mondial 4000 semi-adjustable articulator (Bio-Art Dental Products, Sao Carlos, SP, Brazil) with the wax rim interoclusal relation according to the mandibular metal cast teeth, with the following references: intercondylar distance in M, Bennett angle at 15 degrees, and condylar guide at 30 degrees.

The arrangement of the left anterior teeth started with the carved wax rim serving as a guide to the positions of the central and lateral incisors and canines. The same procedure was used on the right side. The posterior teeth were arranged starting with the first premolar up to the second molar. The same procedure was used in the right arch. The arrangement of the teeth for the interocclusal relationship was anterior vertical overlap and posterior in Angle class I. After finishing the tooth arrangement of the first denture, a silicone (Zetalabor, Zhermack, Rovigo, Italy) matrix was made fitted to all buccal aspects of the denture, comprising the vestibular and incisal surfaces of anterior teeth and vestibular and occlusal surfaces of posterior teeth. The purpose of this matrix was to guide the standardized arrangement of the teeth in all the samples.

Metallic reference pins (Cadena, Coats Textil Ltda., SP, Brazil) were placed with cianoacrylate adhesive (Super Bonder; Loctite, Sao Paulo, SP, Brazil) at the incisal border of the central incisors, buccal cusp of the first premolars, and mesiobuccal cusp of the second molars to serve as reference to quantify tooth movement (Figure 1). Therefore, the following linear distances were considered: RPM-LPM (right premolar to left premolar), RM-LM (right molar to left molar), RI-RM (right incisor to right molar) and LI-LM (left incisor to left molar). The distances were measured with a STM microscope (Olympus Optical Co., Tokyo, Japan), with an accuracy of 0.0005mm.

The casts and wax patterns of the groups I (CLA-MICRO) and IV (ONDA-CRYL) were flasked in the lower part of a traditional brass flask (Safrany; J Safrany Dental Metallurgy, Sao Paulo, SP, Brazil), and the sets of groups II (CLA-WATER) and III (QC-20) were flasked in the lower part of a glass fiber flask (BMF1, Classico Dental Products, Sao Paulo, SP, Brazil) for microwave polymerization with type II dental stone (Pasom; Dental Products, SP, Brazil). Petroleum jelly (Labsynth; Labsynth Chemical Products, Diadema, SP, Brazil) was used as a separating medium between the plaster in the lower part of the flask and the type III dental stone used in the upper portion. After 1 hour the flasks were placed in boiling water to soften the baseplate wax. The flasks were separated, the wax removed, and the stone was cleaned with boiling water and liquid detergent (Ype; Chemical Amparo, SP, Brazil). Two coats of sodium alginate (Isolak; Classico Dental Products, Sao Paulo, SP, Brazil) were used as a mold separator.

The resins were prepared in accordance with the manufacturer's directions and each sample was packed in accordance with the group assignments: Group I (CLA-MICRO): Classico heat-curing acrylic resin (Classico Dental Products, Sao Paulo, SP, Brazil) polymerization for 3 minutes at 35%, 4 minutes at 0%, and 3 minutes at 65% power of the microwave oven (Continental Domestic Products, Manaus, AM, Brazil) Group II (CLA-WATER): Classico heat-curing acrylic resin (Classico Dental Products, Sao Paulo, SP, Brazil) polymerization in water bath at 74°C for 9 hours (control-group) in the thermo-curing unit (Thermotron Dental Products, Piracicaba, SP, Brazil); Group III (QC-20): QC-20 fast heat-curing acrylic resin (Dentsply, Dental Products, RJ, Brazil) processed in boiling water for

20 minutes; Group IV (ONDA-CRYL): Onda-Cryl microwave acrylic resin (Classico Dental Products, Sao Paulo, SP, Brazil) processed at same conditions of Group I.

After polymerization, the flasks of the groups II and III were removed from the microwave oven, and the ones of the groups I and IV were slowly cooled in the water bath, removed from the thermo-curing unit, and all were bench stored for 3 hours. After this period, the dentures were deflasked, polished, and the transverse and anteroposterior distances were measured again. The data collected were submitted to the Analysis of Variance (ANOVA) and Tukey test at 5% level of significance.

Results

Considering all the distances evaluated, some tooth movement occurred but without statistical difference at 5% of significance before and after the polymerization (Tables I, II, III, IV). For the distance RP-LP, the magnitude of tooth movement was greater for CLA-MICRO (Group I) than all other groups of study after the polymerization (Table I). The distances RM-LM, RI-RM, and LI-LM had no significant changes after polymerizing the dentures (Tables II, III, IV).

Table I – Means and standard deviations (mm) of tooth movement for the distance RP-LP considering the polymerization cycle and treatment factor.

Treatment factor	Polymerization cycle			
	CLA-MICRO	CLA-WATER	QC-20	ONDA-CRYL
Before curing	39.07(0.55) Aa	38.70(0.82) Aa	38.65(0.59) Aa	38.24(0.78) Aa
After curing	39.01(0.50) Aa	38.66(0.87) ABa	38.57(0.58) ABa	38.10(0.79) Ba

Means followed by the same capital letters in each row and the same small letters in each column were not significantly different (5%)

Table II – Means and standard deviations (mm) of tooth movement for the distance RM-LM considering the polymerization cycle and treatment factor.

Treatment factor	Polymerization cycle			
	CLA-MICRO	CLA-WATER	QC-20	ONDACRYL
Before curing	51.23(0.85)Aa	51.50 (0.78) Aa	50.97 (0.50) Aa	51.17(0.59) Aa
After curing	51.16(0.72) Aa	51.39(0.81) Aa	50.88(0.46) Aa	50.94(0.58) Aa

Means followed by the same capital letters in each row and the same small letters in each column were not significantly different (5%)

Table III – Means and standard deviations (mm) of tooth movement for the distance RI-RM considering the polymerization cycle and treatment factor.

Treatment factor	Polymerization cycle			
	CLA-MICRO	CLA-WATER	QC-20	ONDACRYL
Before curing	41.79(0.61) Aa	41.70(0.42) Aa	41.55(0.26) Aa	41.68(0.51) Aa
After curing	41.63(0.53) Aa	41.67(0.45) Aa	41.49(0.18) Aa	41.51(0.55) Aa

Means followed by the same capital letters in each row and the same small letters in each column were not significantly different (5%)

Table IV – Means and standard deviations (mm) of tooth movement for the distance LI-LM considering the polymerization cycle and treatment factor.

Treatment factor	Polymerization cycle			
	CLA-MICRO	CLA-WATER	QC-20	ONDACRYL
Before curing	40.62(0.72) Aa	40.70(0.53) Aa	40.67(0.31) Aa	40.68(0.54) Aa
After curing	40.52(0.64) Aa	40.56(0.47) Aa	40.53(0.31) Aa	40.61(0.49) Aa

Means followed by the same capital letters in each row and the same small letters in each column were not significantly different (5%)

Discussion

Dimensional changes may modify the planned vertical occlusion dimension, and cause traumas in mucosa and bone loss. Careful measures have been taken to overcome some inaccuracies such as base distortion and displacement of artificial teeth, factors that lead to loss of stability and retention, and necessity of more difficult occlusal adjustments (1) (McCartney, 1984).

Considering the proposed study tooth movement occurred in all studied interactions; however, the change only had statistical difference (5%) in the distance RP-LP after the polymerization, with higher value for Group I (Table I). Three explanation for this phenomenon may be considered: 1) the denture bases were made with 2mm thickness and, according to previous studies (13,14) (Winkler *et al.*, 1971; Reeson & Jepson, 1999), this fact may reduce dimensional change in the base; 2) the polymerization shrinkage of the resin may be, in part, compensated by the thermal expansion of the own resin during the processing (15) (Kawara *et al.*, 1998); and 3) the restrictive effect of investing plaster on keeping the tooth position when the resin induces polymerization and cooling stresses (16) (Barco *et al.*, 1979). It was also possible that during or after the procedures a great amount of internal stresses was relieved before definitive closure of the flask. Therefore the remaining internal tensions were not able to promote statistically significant tooth movement after deflasking process.

Previous studies reported that the greater degree of base dimensional changes was observed in the denture posterior palatal seal (17,18,19) (Anthony & Peyton, 1959; Polyzois, 1990; Firtell *et al.*, 1981), with changes of posterior teeth position and vertical dimension (19,20) (Wesley *et al.*, 1973; Consani *et al.*, 2006). Only the distance RP-LP presented significant dimensional change and the explanation, as suggested by (21) Lorton & Phillips (1979), may be related to the complexity of variables the characterize the acrylic resin processing. It is possible that other factors generated a great amount of stress in this region, occurring displacement of artificial teeth.

The long cycle polymerization in water bath was reported as preferable because less dimensional change occurs in the base (22) (Stanford & Paffenbarger, 1956). On the order hand the fast cycle is characterized by the occurrence of incomplete polymerization of the resin, with temperature peaks and a great deal of exothermic heat (23) (Yau et al.,2002). Long and fast cycles in water bath studied in the present study were alike in relation to the linear dimensional stability. To explain this phenomenon it's necessary to consider the complexity of all factors that interact during the complete denture processing (24) (Becker *et al*., 1977). The dimensional changes waited in the final of the fast cycle were probably insignificant, or minimized by the action of other processing variables.

Most of distances presented regular dimensional stability after processing, and the microwave polymerization groups had similar behavior than the conventional cycles in water bath ones. Last studies advocated in favor to microwave polymerization highlighting the manipulation pattern of resins, its clinical use and dimensional accuracy (25,26) (Reitz *et al*, 1985; De Clerk, 1987). Other studies reported that basis cured by microwave energy presented the same or a better fit on the cast than others conventionally polymerized (27,28) (Al-Hanbali *et al*., 1991; Levin *et al*., 1989).

It is possible that the energy emitted by microwave generates a little gradient of temperature between the resin and the cast. That uniform heat result in a fast polymerization and a reduction of stress release (29,30) (Hogan & Mori, 1990; Kimura *et al*., 1983), and these aspects would lead to a less dimensional distortion. However, these possible properties of microwave method had little advantage on maintaining the tooth position when compared with the conventional cycles in the present study, especially for CLA-MICRO (GROUP I) in the distance RP-LP. The microwave groups of study (Groups I and IV) were comparable each other for 3 distances (RM-LM, RI-RM, and LI-LM). Braun's study (2000) also verified this aspect, concluding that the conventional resins showed similar dimensional change than those resins specially designed to cure by microwave activation.

Conclusion

From a laboratory point of view, this study showed a similar behavior between microwave method and the conventional cycles in water bath. The use of conventional heat-curing acrylic resin for microwave energy polymerization seems not strongly influence on the tooth position change.

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Figure and legend

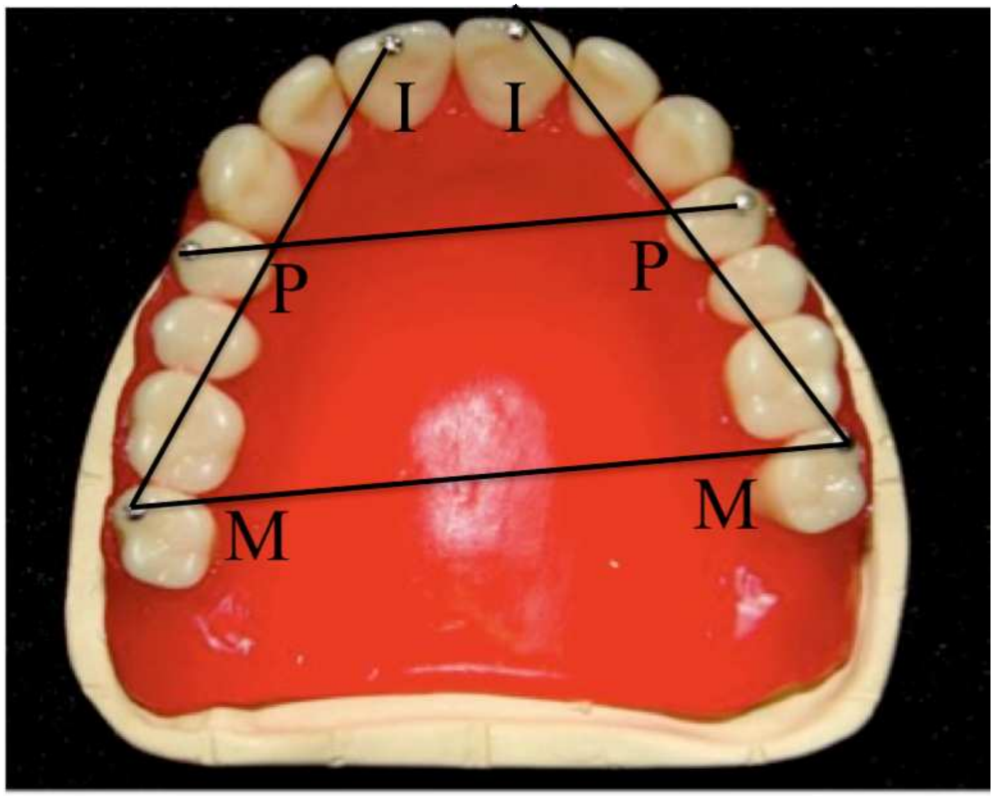

Figure 1 - Metallic reference pins

2- CAPÍTULOS

Artigo científico intitulado "The role of the polymerization cycle and the post-pressing time on the tooth movement in complete dentures" que será submetido à apreciação da Revista *Brazilian Oral Research.*

Prótese Dental

The role of the polymerization cycle and the post-pressing time on the tooth movement in complete dentures

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Abstract

A delay for polymerizing acrylic resin complete dentures after the final pressing step may reduce the stress release and the consequent tooth position change. This study analyzed the influence of the polymerization cycle and the post-pressing time on the tooth movement in complete dentures. Fourty maxillary complete dentures were fabricated and randomly assigned in 8 groups (n=5) varyng the polymerizarion cycle (conventional long cycle in water bath, fast cycle in boiling water, and by microwave energy) and the post-pressing time (immediate and 6 hours). Metal reference pins were placed on the incisal border of the central incisors (RI and LI), vestibular cusp of the first premolars (RP and LP), and the mesio-vestibular cusp of the second molars (RM and LM). Two transverse and 2 anteroposterior distances were measured before and after the complete dentures processing with a linear optical microscope (Olympus Optical Co., Tokyo, Japan) with an accuracy of 0.0005mm. Collected data were submitted to the variance analysis and Tukey test at 5% of significance. Most of the distances analyzed presented no statistical difference in the tooth movement. The tooth movement was statistically significant for Classico conventional heat-curing acrylic resin polymerized by microwave energy for 2 distances, with greater value for the 6-hour post-pressing time. Onda-Cryl microwave acrylic resin processed by microwave energy presented the lowest tooth movement considering the 6-hour post-pressing time for 2 distances. The tooth movement showed an asymmetric behaviour, and the domain of a certain processing method should prevail throughout precise execution of all laboratory steps, independently of the polymerization cycle and post-pressing time used.

Key words: Acrylic resin, tooth movement, artificial tooth, Post-pressing time.

Introduction

Acrylic resin complete dentures undergo unavoidable termal expansion on heating, contraction on cooling, and polymerization contraction. The inherent characteristics of this material produce an internal stress that is released during the deflasking stage, generating dimensional changes and denture base distortion (1) (Braun *et al*., 2000). Some studies investigated other materials and techniques to overcome these problems, and the microwave activation became the target of new studies (2,3) (De Clerk, 1987; Reitz *et al*., 1995). The microwave polymerization is highlighted because its manipulation pattern of resins, its clinical use and dimensional accuracy (4,5) (Blagojevic & Murphy, 1999; Keenan *et al*., 2003). Other reports advocated that the basis cured by this method presented the same or a better fit on the cast than others conventionally polymerized (6,7) (Al-Hanbali *et al*., 1991; Levin *et al*., 1989).

Another aspect that may critically influence on the dimensional changes is the delay in polymerizing the denture after the final pressing step. This procedure alows the resin mass to flow into all regions of the mold and thus relieve internal stress in the early stage after closure. This condition has not been analyzed yet with dentures processed by microwave processing.

Considering the complexity of complete denture processing, the aim of this study was to investigate the effect of the polymerization cycle and the post-pressing time on the teeth displacement in maxilary complete dentures. The use of conventional heat-curing acrylic resin polymerized by microwave activation was also veryfied.

Material and Method

Fourty identical casts were poured from a silicone mold (Elite Double; Zhermack, Rovigo, Italy) of a metal master edentulous maxillary die without irregularities in the alveolar ridge walls. The casts were made of artificial type III dental stone (Herodent Soli-Hock; Vigodent, RJ, Brazil) in a ratio of 30 ml water to 100g powder.

A 2mm thick plate wax (Epoxiglass; Epoxiglass Chemical Products, Diadema, SP, Brazil) measured with a caliper was used to make uniform denture bases. The height of the occlusion wax rim was 20mm in the buccal sulcus of the cast and 10mm in the second molar area. The maxillary stone cast was mounted in a Mondial 4000 semi-adjustable articulator (Bio-Art Dental Products, Sao Carlos, SP, Brazil) with the wax rim interoclusal relation according to the mandibular metal cast teeth, according to the references: intercondylar distance in M, Bennett angle at 15 degrees, and condylar guide at 30 degrees.

Left anterior teeth was arranged with the carved wax rim serving as a guide to the positions of the central and lateral incisors and canines. Similar procedure was used on the right side. The posterior teeth were arranged starting with the first premolar up to the second molar. Similar procedure was used in the right arch. The teeth arrangement for the interocclusal relationship was anterior vertical overlap and posterior in Angle class I. After finishing the tooth arrangement of the first denture, a silicone matrix was made (Zetalabor, Zhermack, Rovigo, Italy) fitted to all buccal aspects of the denture, comprising the vestibular and incisal surfaces of anterior teeth and vestibular and occlusal surfaces of posterior teeth. The purpose of this matrix was to guide the standardized arrangement of the teeth in all the samples.

Metallic reference pins (Cadena, Coats Textil Ltda., SP, Brazil) were fixed with instantaneous adhesive (Super Bonder; Loctite, Sao Paulo, SP, Brazil) at the incisal border of the central incisors, buccal cusp of the first premolars, and mesiobuccal cusp of the second molars to serve as reference to measure tooth movement (Figure 1). The following linear distances were considered: RP-LP (right premolar to left premolar), RM-LM (right molar to left molar), RI-RM (right incisor to right molar), and LI-LM (left incisor to left molar). The linear distances were measured with a STM microscope (Olympus Optical Co., Tokyo, Japan), with an accuracy of 0.0005mm.

The cast and wax pattern sets of the groups I, II, VII, and VIII were flasked in the lower part of a glass fiber flask (BMF1, Classico Dental Products, Sao Paulo, SP, Brazil) for microwave polymerization, and the sets of groups III, IV, V, and VI were flasked in the lower part of a traditional brass flask (Safrany; J Safrany Dental Metallurgy, Sao Paulo, SP, Brazil) with type II dental stone (Pasom; Dental Products, SP, Brazil). Petroleum jelly (Labsynth; Labsynth Chemical Products, Diadema, SP, Brazil) was used as a separating medium between the plaster in the lower part of the flask and the type III dental stone used in the upper portion. After 1 hour, the flasks were placed in boiling water to soften the baseplate wax. The flasks were separated, the wax removed, and the stone was cleaned with boiling water and liquid detergent (Ype; Chemical Amparo, Amparo, SP, Brazil). Two coats of sodium alginate (Isolak; Classico Dental Products) were used as a mold separator.

The resins were proportioned and prepared in accordance with the manufacturer's directions and each sample was packed in accordance with the group assignments: Group I and II (CLA-MICRO): Classico conventional heat-curing acrylic resin (Classico, Classico Dental Products, Sao Paulo, SP, Brazil) polymerized at 3 minutes at 35%, 4 minutes at 0%, and 3 minutes at 65% power of the microwave oven (Continental Domestic Products, Manaus, AM, Brazil); Group III and IV (CLA-WATER): Classico conventional heat-curing acrylic resin (Classico, Classico Dental Products, Sao Paulo, SP, Brazil) polymeriized in water bath at 74°C for 9 hours in a thermo-curing unit (Thermotron Dental Products, Piracicaba, SP, Brazil); Group V and VI (QC-20): QC-20 fast heat-curing acrylic resin (Dentsply, Dental Products, Rio de Janeiro, RJ, Brazil) processed in boiling water for 20 minutes; Group VII and VIII (ONDA-CRYL): Onda-Cryl microwaved acrylic resin (Classico Dental Products, Sao Paulo, SP, Brazil) processed at same conditions of Group 1. The groups I, III, V, and VII were polymerized immediately after the pressing stage, while the groups II, IV, VI, and VIII delayed 6 hours to do that.

After polymerization, the flasks of the groups I, II, VII, and VIII were removed from the microwave oven, and the ones of the groups III, IV, V, and VI were slowly cooled in the water bath, removed from the thermo-curing unit, and bench stored for 3 hours. After cooling, the dentures were deflasked, polished, and the transverse and anteroposterior distances were measured again. Collected data were submitted to the Analysis of Variance (ANOVA) and Tukey test at 5% level of significance.

Results

Considering the 6-hour post-pressing time, and for the distances RP-LP and RI-RM, group VIII (ONDA-CRYL) presented statistically ($p<0.05$) lesser tooth movement than all other groups (Tables 1 and 3). Inside of CLA-MICRO groups, and for the distances RM-LM and LI-LM, the tooth movement was statistically significant greater ($p<0.05$) for the group II (Tables 2 e 4).

Table 1 – Means and standard deviations (mm) of tooth movement for the distance RP-LP considering the polymerization cycle and the post-pressing time.

Post-pressing time	Polymerization cycle			
	CLA-MICRO	CLA-WATER	QC-20	ONDA-CRYL
Immediate	I - 39.02 (0.46)Aa	III- 38.31(0.83) Ab	V- 38.64 (0.55)Aa	VII- 38.39(0.76)Aa
6-hour	II- 39.07(0.59)Aa	IV- 39.04(0.66) Aa	VI- 38.58(0.63)ABa	VIII- 37.96(0.75)Ba

Means followed by the same capital letters in each row and the same small letters in each column were not significantly different (5%)

Table 2 – Means and standard deviations (mm) of tooth movement for the distance RM-LM considering the polymerization cycle and the post-pressing time.

Post-pressing time	Polymerization cycle			
	CLA-MICRO	CLA-WATER	QC-20	ONDA-CRYL
Immediate	I- 50.81(0.86) Ab	III- 51.35(0.75) Aa	V- 50.90(0.38) Aa	VII- 51.23(0.71) Aa
6-hour	II- 51.58(0.44) Aa	IV- 51.54(0.83) Aa	VI- 50.96(0.57) Aa	VIII- 50.88(0.39) Aa

Means followed by the same capital letters in each row and the same small letters in each column were not significantly different (5%)

Table 3 – Means and standard deviations of tooth movement for the distance RI-RM considering the polymerization cycle and the post-pressing time.

Post-pressing time	Polymerization cycle			
	CLA-MICRO	CLA-WATER	QC-20	ONDA-CRYL
Immediate	I- 41.46(0.66)ABb	III- 41.62(0.38) Aa	V- 41.13(0.26) Ba	VII- 41.76(0.27) Aa
6-hour	II- 41.96(0.32) Aa	IV- 41.75(0.48) Aa	VI- 41.11(0.19) Ba	VIII- 40.92(0.33) Bb

Means followed by the same capital letters in each row and the same small letters in each column were not significantly different (5%)

Table 4 – Means and standard deviations (mm) of tooth movement for the distance LI-LM considering the polymerization cycle and the post-pressing time.

Post-pressing time	Polymerization cycle			
	CLA-MICRO	CLA-WATER	QC-20	ONDACRYL
Immediate	I- 40.30(0.84) Ab	III- 40.62(0.50) Aa	V- 40.56(0.15) Aa	VII- 40.56(0.39) Aa
6-hour	II- 40.84(0.26) Aa	IV- 40.65(0.52) Aa	VI- 40.64(0.42) Aa	VIII- 40.72(0.61) Aa

Means followed by the same capital letters in each row and the same small letters in each column were not significantly different (5%)

Discussion

The seek for an efficient laboratory technique to make complete dentures that be practical, fast, aesthetic, and without great dimensional changes go on a challenge. As suggested by (8) Lorton & Phillips (1979), the dimensional changes that occur in acrylic resin dentures are complex, and many processing variables interact one another at the same time.

In the present study, it becomes difficult to choice a best processing technique among the eight ones analyzed. A classical study reported that the long cycle processed in water bath is recomendable due to the occurrence of lower dimensional change in the base (9) (Stanford & Paffembarger, 1956). However this method had similar behaviour than the others considering the magnitude of tooth movement in most of distances evaluated. In the fast cycle in boiling water, however, incomplete polymerization of the resin may occur, because of the rapid heating with temperature peaks, generating a great deal of exothermic heat (10) (Yau *et al*., 2002). In the present study, long and fast cycles in water bath were alike in relation to the dimensional stability, and this phenomenon also characterizes the complexity of all the factors that interact during complete denture processing (11) (Becker *et al*., 1977). The thermal and polymerization shrinkage obtained in the fast cycle were probably insignificant, or minimized by the action of other variables.

Producing big molecular interactions, condensing more the moleculas, and contracting the final structure after the polymerization characterize the water bath convencional cycle. On the other hand, the microwave activation permits a faster and more intense energy, with interactions able to join monomer and polymer and cure the resin (12) (Skinner, 1993). The basis cured by this method presented the same or a better fit on the cast than others conventionally polymerized (6,7) (Al-Hanbali *et al*., 1991; Levin *et al*., 1989). However, these reports advocate in favor to the microwave processing method, its superiority was not verified in this study for most of distances evaluated. Only for 2 distances, group VIII (ONDA-CRYL) presented statistically ($p<0.05$) lower tooth movement than all other groups (Tables I and III).

The use of conventional heat-curing acrylic resins for microwave polymerization had no great damage in this study; however, a previous study have reported the occurrence of more changes like porosities due to the applycation of that material (13) (Yannikakis *et al.,* 2002). The microwave energy generated by the "magnetron" of the microwave oven may produce a dietric heating in which the energy is imediately and uniformly absorved by the resin. This method may reduce the time of heat transference from the water to the flask, from the flask to the cast, and from the cast to the resin, as occur in the conventional cycle polymerization (14) (Walace *et al*., 1991). The described phenomen probably occurs for all resin types in this study, independently of their components, causing similar dimensional changes in tooth position. That finding is in accordance with the (1) Braun's study (2000) that concluded the conventional heat-curing acrylic resins showed similar dimensional change than those resins specially designed to cure by microwave activation.

The 6-hour post-pressing time was chosen as a variable, because it seems to be the minimum and effective period for demonstrating resin relaxation, and at the same time, a possible technical condition to be applied in the laboratory routine. One reason for allowing the flask to stand for some hours before polymerizing would be to reduce the amount of residual monomer preent in the resin dough (15) (Peyton, 1950). In the present report, the 6-hour post-pressing time had no advantage on reducing the magnitude of tooht movement in most of distances evaluated. This procedure had no significant effect on alowing the resin mass to flow into all regions of the mold and relieve internal stress, and generate a lower dimensional change.

It is obvious that irrespective of the polimerization cycle and post-pressing time used, the complexity of the stresses in the denture also involves other important factors that generate displacement of the artificial teeth. The many findings in the literature verifying that tooth movement showed no differences among the tested groups (16,17) (Garfunkel 1983; Consani *et al*., 2006), as opposed to other studies that showed that there was a best method (5,18) (Keenan *et al*.,2003; Polyzois *et al*., 1987) maintain this subject open for further investigations.

Conclusion

According to the metodology of this study, the microwave polymerization had similar performace than the conventional cycles in water bath, and the post-pressing time had no relevent effect on the tooth movement. This study verified an asymmetric linear tooth movement among the processing groups, without much evidence to enable one to determine the best processing group. Therefore, whatever technique is used for processing needs to be meticulously controlled.

Acknowledgments

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Figure and legend

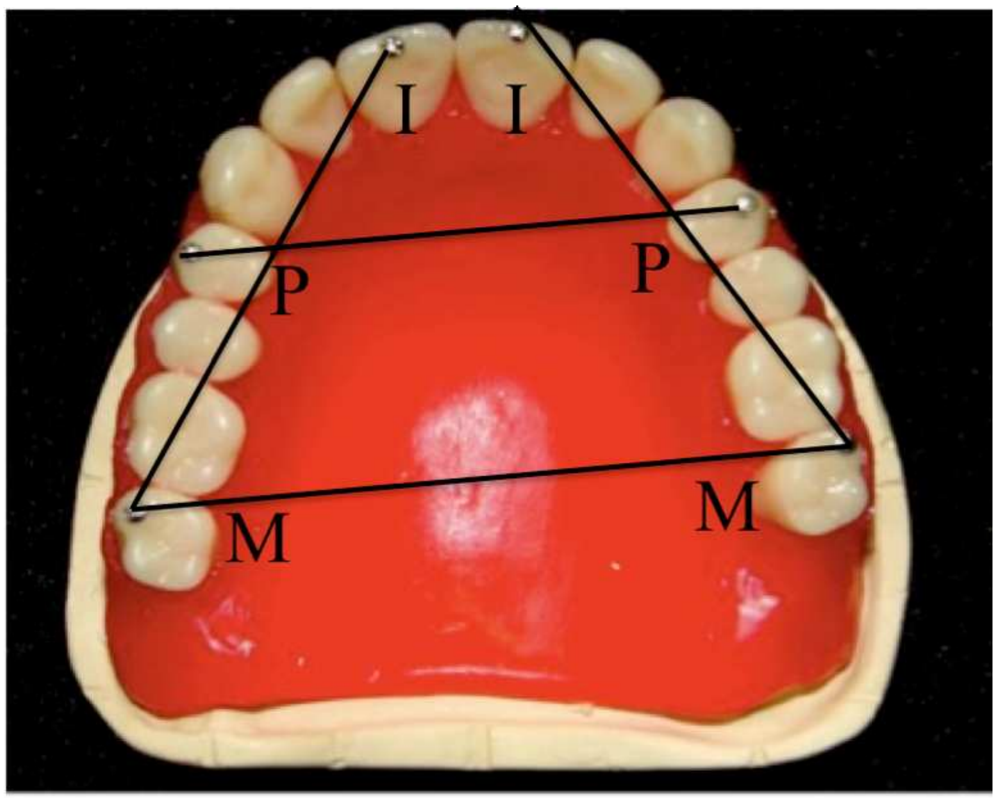

Figure 1 - Metallic reference pins.

3- CONSIDERAÇÕES GERAIS

Por volta de 1940, 95% das próteses feitas nos Estados Unidos já eram confeccionadas com polimetilmetracrilato. Apesar do longo tempo de uso clínico e laboratorial, a aplicação desse material ainda exige critérios rígidos de observação e de cuidados e ainda instiga os pesquisadores à realização de novas investigações científicas. O processamento de próteses totais é bastante complexo, variando tanto pelas características inerentes à própria composição dos materiais de processamento, como é o caso da diferença do coeficiente de expansão da resina e do gesso ou da presença de monômero livre não polimerizado na resina, como pela escolha, por exemplo, de um método de polimerização por luz, calor úmido ou por microondas. Esses fatores respondem pela ocorrência de alterações dimensionais dificilmente evitáveis durante a confecção de próteses totais (Baronini Neto *et al*., 1998).

A investigação sobre o desempenho dos ciclos de polimerização considerando a ocorrência de alterações dimensionais é bem documentada na literatura (Blagojevic & Murphy, 1999; Goiato *et al*., 2000; Keenan *et al*., 2003). No presente estudo, comparou-se 3 diferentes métodos de polimerização de próteses totais: 1) ciclo longo em água aquecida: no qual ocorre uma reação em cadeia que requer a ativação de um iniciador (peróxido de benzoíla) que origina o primeiro radical livre, desencadeando todo o restante das reações pela liberação da dupla ligação das moléculas de metilmetacrilato, com liberação de calor que pode alcançar temperaturas de até 100.8° (Skinner, 1984); 2) ciclo rápido em água em ebulição: caracterizado por um rápido aquecimento da resina em altas temperaturas, alcançando altos picos de temperatura e gerando grande quantidade de calor exotérmico, podendo não polimerizar completamente a massa interna da resina (Yau *et al*., 2002); 3) ativação por energia de microondas: energia elétrica é em convertida em microondas, as quais geram pequeno gradiente de temperatura entre a resina e o molde gesso, havendo aquecimento uniforme, resultando rápida polimerização e conseqüente diminuição dos estresses de processamento (Rizzatti-Barbosa *et al.*,1995).

Mesmo com 3 diferentes mecanismos de ação, os ciclos de polimerização testados foram semelhantes no desempenho da maioria das distâncias avaliadas, nas resinas e nos tempos pós-prensagem pesquisados. A grande contribuição dessa pesquisa à prática laboratorial das próteses totais aponta-se na possibilidade de uso da energia de microondas, com ou sem resinas designadas para esse método, sem a perda do padrão oclusal, anteriormente planejado na fase de prova da prótese (dentes fixados em cera), com resultados comparáveis ao ciclo convencional em banho de água aquecida (grupo controle).

Particularmente, existe facilitação dos procedimentos quando se trabalha com próteses polimerizadas por microondas. Inicialmente, a própria mufla de fibra de vidro é facilmente isolada no início e limpa ao final do ciclo de cura. O fechamento da mufla com parafusos é um procedimento simples no momento da prensagem final, dispensando o uso de grampo metálico de fixação, o qual exige esforço durante a aplicação. O tempo total de cura da resina se aproxima de 10 minutos em alguns ciclos de polimerização, facilitando bastante a rotina laboratorial. É possível destacar também que as próteses podem ser confeccionadas com resinas apropriadas ou mesmo com resinas convencionais para polimerização em banho de água aquecida, sem que haja grande alteração dimensional, funcional e estética ao final do processamento.

A busca por um período de espera após a etapa de prensagem final que seja vantajoso em reduzir alterações dimensionais nas próteses totais foi bem relatada na literatura, apesar dos obtidos resultados serem conflitantes em tais pesquisas (Kimpara & Muench, 1996; Consani *et al.*, 2001; Consani *et al.*, 2004). Neste trabalho, o tempo pós-prensagem de 6 horas não mostrou ser superior à polimerização imediata após prensagem, não se justificando esse procedimento principalmente quando se emprega a polimerização por microondas, considerando que nesse método o tempo é uma vantagem bastante relevante. A premissa de que o tempo de espera para polimerização permitiria maior acomodação da massa da resina dentro do molde, com relaxamento das tensões e redução da quantidade de monômero residual livre não foi suficiente para influenciar a movimentação dental, ou foi contrabalançada pela ação de outros fatores de processamento não considerados neste estudo.

Nesse sentido, a pesquisa com diferentes ciclos de polimerização em prótese total é tarefa difícil devido à necessidade de um rígido controle de todas as demais variáveis que influenciam o processo. Conforme ocorreu no presente trabalho, apesar do rígido controle da metodologia os ciclos testados parecem não evidenciar diferença estatística significativa que permita a escolha do melhor método. Este fato dificulta a interpretação dos dados obtidos, pois em algumas das distâncias avaliadas houve liberação de tensões suficiente para um deslocamento dental significativo, ao passo que não se observou o mesmo na distância contra-lateral.

Parece prudente afirmar, portanto, que qualquer que seja o ciclo de polimerização escolhido deve-se respeitar e seguir criteriosamente todas as etapas da elaboração da prótese (tempo, temperatura, proporção, manipulação, etc.), pois é o domínio sobre a técnica de polimerização que responderá pelo sucesso laboratorial e clínico da prótese total em uso. A busca por métodos efetivos de polimerização que reduzam a magnitude das alterações dimensionais não elimina a necessidade de ajuste oclusal em articulador, por meio do procedimento de remontagem das próteses após o processamento, bem como de ajustes clínicos intra-orais no momento da instalação das próteses totais.

4- CONCLUSÃO

De acordo com a metodologia empregada neste estudo laboratorial, no qual se investigou a movimentação dental linear em prótese total superior, confeccionada em diferentes ciclos de polimerização e tempos pós-prensagem, pôde-se delinear as seguintes conclusões:

1- A movimentação dental não mostrou padrão específico ou simétrico, variando em relação ao tipo de resina, distância, ciclo de polimerização e tempo pós-prensagem analisados;

2- Os ciclos de polimerização (ciclo longo em banho de água aquecida, ciclo rápido em água em ebulição e ciclo ativado por energia de microondas) promoveram movimentação dental similar na maioria das distâncias avaliadas;

3- A resina acrílica Clássico (ciclo longo em banho de água aquecida) apresentou movimentação dental com resultados estatísticos similares à resina Onda-Cryl (energia de microondas);

4- O tempo pós-prensagem 6-horas não reduziu estatisticamente a magnitude do deslocamento dental na maioria das interações avaliadas.

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6- APÊNDICE

DELINEAMENTO EXPERIMENTAL

GRUPO 1 - Prensagem final da resina **Clássico** e início **imediato** da polimerização em **banho de água a 74ºC por 9 horas**.

	Antes					Depois				
Modelo	**Id-Ie**	**PMd-PMe**	**Md-Me**	**Id-Md**	**Ie-Me**	**Id-Ie**	**PMd-PMe**	**Md-Me**	**Id-Md**	**Ie-Me**
1	**7,60**	**37,27**	**50,52**	**41,01**	**40,41**	**7,84**	**37,09**	**50,29**	**40,96**	**40,01**
2	**7,66**	**38,70**	**51,66**	**41,83**	**40,82**	**7,62**	**38,50**	**51,54**	**41,77**	**40,75**
3	**7,56**	**38,27**	**52,07**	**41,97**	**41,37**	**7,48**	**38,37**	**52,01**	**41,88**	**41,22**
4	**7,38**	**39,64**	**52,09**	**41,56**	**40,94**	**7,34**	**39,50**	**52,12**	**41,48**	**40,71**
5	**7,94**	**37,97**	**50,70**	**41,76**	**39,95**	**7,70**	**37,87**	**50,55**	**42,08**	**40,05**

GRUPO 2 - Prensagem final da resina **Clássico** e início após **6 horas** da polimerização em **banho de água a 74ºC por 9 horas**.

	Antes					Depois				
Modelo	**Id-Ie**	**PMd-PMe**	**Md-Me**	**Id-Md**	**Ie-Me**	**Id-Ie**	**PMd-PMe**	**Md-Me**	**Id-Md**	**Ie-Me**
6	**7,55**	**38,08**	**51,03**	**42,48**	**40,71**	**7,41**	**37,98**	**50,93**	**42,25**	**40,72**
7	**7,89**	**38,82**	**50,52**	**41,10**	**39,99**	**7.84**	**38,95**	**50,42**	**40,92**	**39,83**
8	**7,83**	**39,25**	**52,83**	**41,72**	**40,59**	**7,84**	**39,32**	**52,69**	**41,62**	**40,48**
9	**7,34**	**39,11**	**51,96**	**41,99**	**41,64**	**7,40**	**39,03**	**51,92**	**42,07**	**41,21**
10	**7,89**	**39,96**	**51,66**	**41,66**	**40,67**	**7,92**	**40,00**	**51,48**	**41,77**	**40,71**

GRUPO 3 – Prensagem final da resina **Clássico** e início **imediato** da polimerização em forno **de microondas** com potência de 1.100 watts, em ciclo de: 3 minutos a 28% da potência, 4 minutos a 0% da potência e 3 minutos a 65% da potência.

	Antes					Depois				
Modelo	**Id-Ie**	**PMd-PMe**	**Md-Me**	**Id-Md**	**Ie-Me**	**Id-Ie**	**PMd-PMe**	**Md-Me**	**Id-Md**	**Ie-Me**
11	**6,94**	**38,53**	**49,59**	**42,41**	**40,65**	**6,91**	**38,54**	**49,90**	**41,90**	**40,47**
12	**6,05**	**39,68**	**51,38**	**41,64**	**40,38**	**6,03**	**39,54**	**51,26**	**41,54**	**40,21**
13	**7,19**	**39,28**	**49,88**	**40,31**	**39,14**	**7,14**	**39,32**	**49,96**	**40,32**	**39,13**
14	**7,11**	**38,42**	**51,68**	**41,82**	**39,82**	**7,13**	**38,62**	**51,71**	**41,77**	**40,12**
25	**6,81**	**39,25**	**51,46**	**41,53**	**41,62**	**6,80**	**39,07**	**51,38**	**41,41**	**41,52**

GRUPO 4- Prensagem final da resina **Clássico** e início após **6 horas** da polimerização em forno de **microondas** com potência de 1.100 watts, em ciclo de: 3 minutos a 28% da potência, 4 minutos a 0% da potência e 3 minutos a 65% da potência.

	Antes					Depois				
Modelo	**Id-Ie**	**PMd-PMe**	**Md-Me**	**Id-Md**	**Ie-Me**	**Id-Ie**	**PMd-PMe**	**Md-Me**	**Id-Md**	**Ie-Me**
16	**6,60**	**39,14**	**51,80**	**41,95**	**40,94**	**6,65**	**39,00**	**51,61**	**41,74**	**40,76**
17	**6,47**	**38,72**	**51,47**	**41,79**	**40,59**	**6,44**	**38,59**	**51,29**	**41,64**	**40,48**
18	**6,65**	**39,50**	**52,42**	**42,62**	**41,33**	**6,65**	**39,41**	**52,23**	**42,46**	**41,16**
19	**6,54**	**38,33**	**51,46**	**42,04**	**40,78**	**6,54**	**38,26**	**51,25**	**41,84**	**40,60**
20	**6,57**	**39,94**	**51,21**	**41,87**	**41,01**	**6,56**	**39,84**	**51,08**	**41,68**	**40,80**

GRUPO 5- Prensagem final da resina **Onda-Cryl** e início **imediato** da polimerização em forno de **microondas** com potência de 1.100 watts, em ciclo de: 3 minutos a 28% da potência, 4 minutos a 0% da potência e 3 minutos a 65% da potência.

	Antes					Depois				
Modelo	Id-Ie	PMd-PMe	Md-Me	Id-Md	Ie-Me	Id-Ie	PMd-PMe	Md-Me	Id-Md	Ie-Me
21	6,96	39,33	51,89	42,10	40,82	6,91	39,11	51,60	42,16	40,84
22	7,47	38,90	51,18	41,56	40,62	7,51	38,88	50,97	41,45	40,50
23	7,43	37,18	50,53	41,71	39,90	7,43	37,02	50,29	41,85	40,04
24	7,24	38,39	50,85	42,02	40,49	7,26	38,21	50,58	41,90	40,33
25	7,67	38,51	52,26	41,54	41,09	7,60	38,40	52,20	41,39	41,01

GRUPO 6- Prensagem final da resina **Onda-Cryl** e início da polimerização após **6 horas** da prensagem, em forno de **microondas** com potência de 1.100 watts, em ciclo de: 3 minutos a 28% da potência, 4 minutos a 0% da potência e 3 minutos a 65% da potência.

	Antes					Depois				
Modelo	Id-Ie	PMd-PMe	Md-Me	Id-Md	Ie-Me	Id-Ie	PMd-PMe	Md-Me	Id-Md	Ie-Me
26	8,02	37,58	50,31	40,72	40,74	8,02	37,62	50,26	40,58	40,68
27	7,80	37,09	51,56	40,50	40,56	7,81	36,78	51,04	40,61	40,63
28	7,58	39,17	50,98	41,43	39,92	7,59	38,99	50,73	41,37	39,81
29	7,43	38,38	51,21	41,21	41,78	7,46	38,20	51,04	41,03	41,59
30	7,27	37,96	50,97	41,07	40,88	7,31	37,84	50,77	40,78	40,70

GRUPO 7- Prensagem final da resina **QC-20** e início **imediato** da polimerização em **água em ebulição por 20 minutos**.

	Antes					Depois				
Modelo	Id-Ie	PMd-PMe	Md-Me	Id-Md	Ie-Me	Id-Ie	PMd-PMe	Md-Me	Id-Md	Ie-Me
31	8,06	38,02	51,12	41,13	40,80	8,03	37,95	50,95	41,03	40,72
32	7,41	39,06	50,96	40,90	40,70	7,29	38,93	50,79	40,86	40,52
33	7,58	38,50	50,36	40,92	40,47	7,60	38,42	50,95	40,84	40,31
34	7,59	39,47	51,51	41,52	40,65	7,56	39,45	51,41	41,44	40,53
35	6,99	38,38	50,59	41,44	40,56	7,06	38,22	50,42	41,28	40,41

GRUPO 8- Prensagem final da resina **QC-20** e início após **6 horas** da polimerização em **água em ebulição por 20 minutos**.

	Antes					Depois				
Modelo	Id-Ie	PMd-PMe	Md-Me	Id-Md	Ie-Me	Id-Ie	PMd-PMe	Md-Me	Id-Md	Ie-Me
36	7,66	38,84	50,04	41,04	39,97	7,65	38,78	49,84	41,00	39,82
37	7,27	37,98	51,35	41,18	40,83	7,24	37,85	51,17	41,06	40,73
38	7,67	39,73	51,48	41,43	41,20	7,68	39,54	51,32	41,23	40,97
39	7,69	38,31	50,97	40,71	40,83	7,59	38,42	50,83	41,08	40,64
40	7,02	38,28	51,40	41,29	40,77	6,97	38,16	51,22	41,18	40,73

DECLARAÇÃO

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