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Effect of Flasking and Polymerization Techniques on Tooth Movement in Complete Denture Processing

Ricardo Shibayama, DDS, MS,[1] Humberto Gennari Filho, DDS, MS, PhD,[2] José Vitor Quinelli Mazaro, DDS, MS,[3] Eduardo Vedovatto, DDS, MS,[3] & Wirley Gonçalves Assunção, DDS, MS, PhD[4]

[1] Professor of Dental Prostheses and Occlusion, Department of Restorative Dentistry, Londrina State University, Brazil
[2] Professor, Chairman, Department of Prosthodontics and Dental Materials, the School of Dentistry at Aracatuba, Sao Paulo State University, Brazil
[3] Master's Degree in Dentistry with major in Dental Prostheses, the School of Dentistry at Aracatuba, Sao Paulo State University, Brazil
[4] Assistant Professor, Department of Prosthodontics and Dental Materials, the School of Dentistry at Aracatuba, Sao Paulo State University, Brazil

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Correspondence
José Vitor Quinelli Mazaro, Rua Euclides da Cunha 451, CEP 16210-000, Bilac/São Paulo, Brazil. E-mail: zevitormazaro@terra.com.br

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Abstract

Purpose: The purpose of this study was to compare the artificial tooth positional changes following the flasking and polymerization of complete dentures by a combination of two flasking methods and two polymerization techniques using computer graphic measurements.

Materials and Methods: Four groups of waxed complete dentures (n = 10) were invested and polymerized using the following techniques: (1) adding a second investment layer of gypsum and conventional water bath polymerization (Control), (2) adding a second investment layer of gypsum and polymerization with microwave energy (Gypmicro), (3) adding a second investment layer of silicone (Zetalabor) and conventional polymerization (Silwater), and (4) adding a second investment layer of silicone and polymerization with microwave energy (Silmicro). For each specimen, six segments of interdental distances (A to F) were measured to determine the artificial tooth positions in the waxed and polymerized stages using software program AutoCad R14. The mean values of the changes were statistically compared by univariate ANOVA with Tukey post-hoc test at 5% significance.

Results: There were no significant differences among the four groups, except for segment D of the Silmicro group (-0.004 ± 0.032 cm) in relation to the Gypwater group (0.044 ± 0.031 cm) ($p < 0.05$), which presented, repectively, expansion and shrinkage after polymerization.

Conclusions: Within the limitations of this study, it was concluded that although the differences were not statistically significant, the use of a silicone investment layer when flasking complete dentures resulted in the least positional changes of the artificial teeth regardless of the polymerization technique.

Changes in artificial tooth position occur when processing complete dentures.[1,2] To overcome these undesirable processing effects, various flasking and polymerization techniques and materials have been studied.[2–23] Several authors have proposed the use of a silicone layer cap[4,6,9,10,17] rather than a gypsum layer cap during flasking.[10,18,19] This silicone cap has been described as a layered silicone rubber mold,[4] a silicone separating medium,[9] and a cover made of a silicone material.[10] The advantages of a silicone layer include ease of application, improved cleanliness, creation of smoother denture surfaces, and greater ease in deflasking and polishing the polymerized denture.[9] According to Marcroft et al,[4] Reisbick,[6] and Zakhari,[7] a minor degree of change was found when comparing silicone to a gypsum layer; however, Tucker and Freeman,[5] Becker et al,[8] Mainieri et al,[10] and Turck et al,[14] reported that no significant difference was shown between silicone and gypsum layer cap.

With regard to polymerization, techniques employing microwave energy have been recommended[11–13,15,16,20,21] rather than conventional water bath polymerization systems,[12,21,22] because the use of microwave has been shown to reduce polymerization time, shorten dough-forming time, provide a more homogeneous dough, and result in improved adaptation of the

denture base.[23] In contrast, there are also disadvantages such as the need for non-metal flasks and the difficulty in establishing an ideal time/microwave power relationship that could enhance the intrinsic characteristics of acrylic resin.[20] When conventional water bath and microwave energy were compared, some authors[11,15,16,23] found no difference between the two techniques; however, these results are not in agreement with others.[12,13] Sanders et al[12] observed in their study that microwave polymerization provided a lower degree of artificial tooth movement, while Nelson et al[13] reported a greater degree of tooth positional changes when microwave polymerization was employed. Although many studies have compared different investing mediums[3-10,24] or polymerization techniques,[11-14,23] the authors could not identify studies published concerning the outcomes provided by the combination of different flasking methods and polymerization techniques.

Finally, several measurement aids have been reported in the literature, including: comparator microscope,[2] vernier caliper,[5] digital caliper,[7] micrometer microscope,[9] and the Michigan Computer-Graphics Coordinate Measurement System.[14] In this study, computer software was used to record artificial tooth positional change measurements. This method allows for storage of the images on a computer, so the measurements may be performed at any moment and any place without distortions. Furthermore, the method is less time-consuming and presents a high degree of accuracy in relation to the microscope or the digital caliper. Therefore, the purpose of this investigation was to assess, by means of computer graphics, positional changes of artificial complete denture teeth using four combinations of flasking methods and polymerization techniques.

Materials and methods

The experimental design included a control group processed conventionally, invested with gypsum layers, and polymerized in a water bath, and three experimental groups. Two brands of acrylic resins were used: one specifically designed for microwave polymerization (Onda-Cryl, Artigos Odontológicos Clássico Ltd, Sao Paulo, Brazil) and the other for water bath polymerization (QC20 Clássico, Artigos Odontológicos Clássico Ltd).

Cast and complete denture duplication

Forty maxillary dentures were duplicated and assigned to four groups (n = 10). To standardize the specimens, two silicone matrixes were fabricated for cast and complete denture duplication. An edentulous maxillary cast with a uniform 3 mm labial border was used as the standard cast (Fig 1). The cast was placed in a cylinder-shaped, glass-bottomed plastic container, and high-viscosity silicone rubber (Silibor, Artigos Odontológicos Clássico) was poured over it to prepare the silicone matrix. Forty casts were fabricated in ADA type II dental stone, Specification 25 (Herodent, Vigodent SA Ind Co, Rio de Janeiro, Brazil).

For the standard cast, a complete maxillary denture was processed. Without separating it from the cast, wax indices (Wilson, Polidental Ind Co Ltd, Sao Paulo, Brazil) were fixed to the polymerized complete denture/cast set in locations, namely, labially to the midline and buccally to the contact point between right and left first and second molars (Fig 2). Then, silicone was poured, as described above, and a complete denture/cast silicone (Silibor) matrix was made. The wax indices fixed at the three locations provided three index impressions in the matrix to allow hot wax to flow. To duplicate the dentures, artificial teeth (Biotone, Dentsply Ind Com, Rio de Janeiro, Brazil) were first positioned in the matrix following the arrangement, and then two sheets of wax (Wilson, Polidental Ind Co) were melted and poured into the matrix. The duplicated cast was completely seated into the matrix was and maintained by hand compression. Surplus wax was eliminated through the indices. After the wax hardened for a minimum time period, 20 minutes room temperature, the duplicated trial denture was removed, and excess wax was eliminated. One examiner repeated this procedure until forty trial maxillary dentures were duplicated.

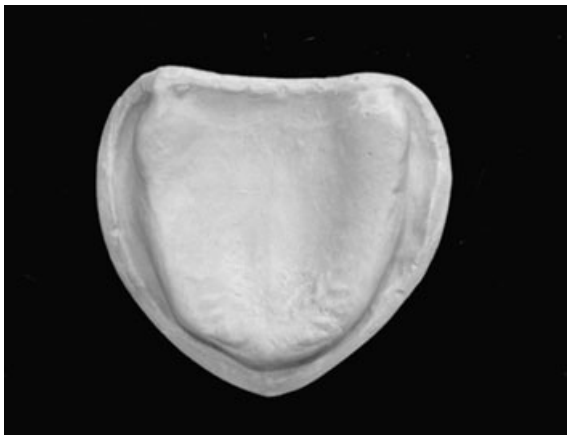

Figure 1 Edentulous maxillary cast.

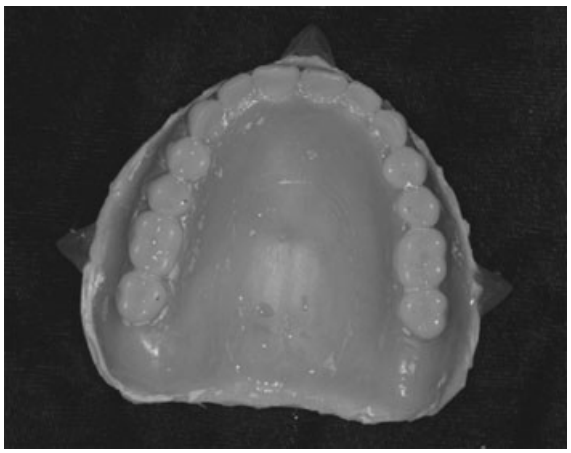

Figure 2 Wax indices fixed to the polymerized complete denture/cast set labially to the midline and buccally to the contact point between right and left first and second molar.

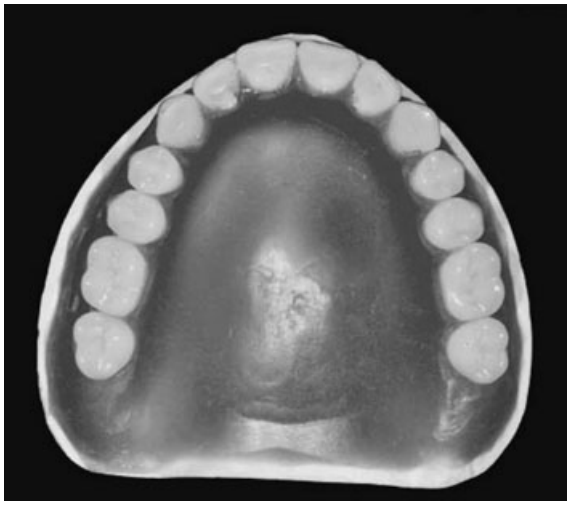

Figure 3 Complete denture at the waxed stage.

Establishing and transferring reference points for measurement

When the complete denture was at the waxed stage (Fig 3), five reference points for measurements were marked with a 0.5 mm sharpened custom metal point and stained with pencil lead in the following locations: on the mesial third of the incisal edge of the left central incisor, on the lingual cusps of the second premolars, and on the mesiolingual cusps of the second molars (Fig 4). Over the occlusal surface of the waxed denture, a colorless acrylic resin template (Clássico; Artigos Odontológicos Clássico Ltd) was fabricated. Perforations were made where the five previously marked points were visualized through the template. Once perforated, the template was occluded against each duplicated denture so the examiner was able to transfer the points marked on the standard to the duplicated waxed dentures.

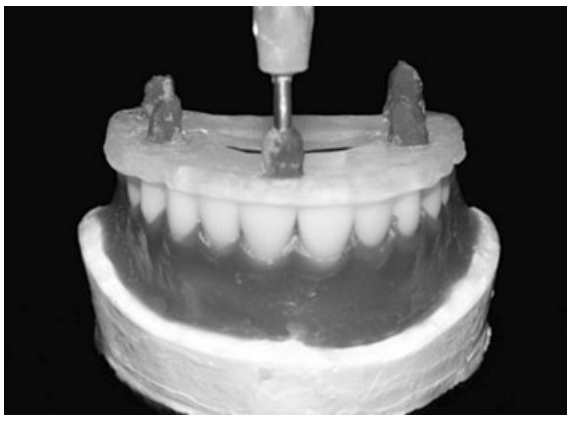

Figure 4 Acrylic resin guide for marking the points.

Computer graphic measurement of the points

For each specimen, an examiner made measurements prior to and following polymerization of the resin without separating the denture/cast set. Six segments that connected the previously marked points were measured for this study (Fig 5): A—distance between the mesiolingual cusps of seconds molars, B—distance between the mesiolingual cusp of the right second molar and left incisal edge, C—distance between the lingual cusp of the left second premolar and left incisal edge, D—distance between the lingual cusps of the second premolar, E—distance between the lingual cusp of the right second bicuspid and left incisal edge, and F—distance between the cusps of the left incisal edge and left second molar. All measurements were performed three times, and their mean values were calculated.[8] To take the measurements, the occlusal surface of each denture was scanned along with a metal block measuring $1 \times 1 \times 1$ cm^3 (Scan Jet 6100C, Hewlett Packard, Palo Alto, CA), and the image was exported to a software program (AutoCad R14, AutoDesk do Brasil Ltd, Sao Paulo, Brazil). Initially, for image digitalization, the actual image dimensions were restored by the "ALIGN" command, with the metal block as the parameter. For measurements, the image was magnified by the "ZOOM" command until the center of each stained point could be seen. Then, by using "aligned dimension" in the dimension toolbar, the first extremity was fixed in the center of one point and run to the center of another point, also magnified to provide accuracy. When two points were connected by "aligned dimension," the dimension value was immediately displayed on the screen. These procedures, from exporting the image through making the measurements, were repeated three times for each specimen, and their average values were used for the study. Although the accuracy of the measurement system may reach more than six decimal places, all measurements were made in centimeters and reported to three decimal places, following the customized configuration of the software user.

Trial denture flasking

Half the dentures were invested in metal flasks (Uraby Produtos Odontológicos, Sao Paulo, Brazil), and half were invested in fiberglass flasks (Clássico). For dentures invested in metal flasks, the upper and lower halves of the flask were matched to achieve metal-to-metal contact, and then they were thoroughly cleaned. All casts/dentures were invested in the lower half of the flasks using plaster of Paris (Clássico). Ten specimens (Gypwater group) were invested in metal flasks using ADA type III dental stone (Herodent) as the second investment layer. The stone was added until the occlusal surfaces and incisal edges of the teeth were covered. After the dental stone had set, a third cap layer of dental stone was used to complete the investment. The flask was closed under a hydraulic pressure of 1000 kg. Ten specimens (Gypmicro group) were invested in fiberglass flasks using the same technique as described for the Gypwater group. Ten specimens (Silwater group) were invested in metal flasks using a layer of approximately 3 mm of silicone rubber (Zetalabor, Zhermarck S.p.A, Badia Polesine, Rovigo, Italy), then the flask was filled with dental stone. Ten specimens (Silmicro group) were invested in a fiberglass flask using a

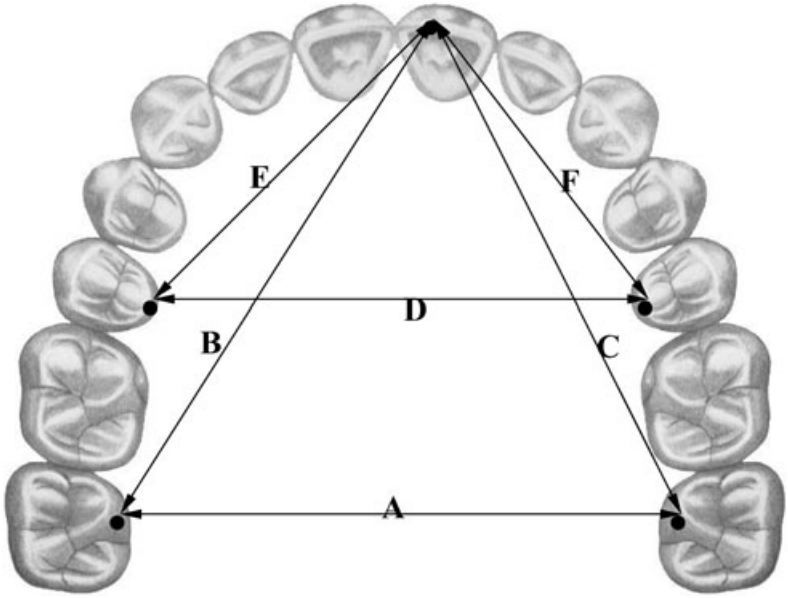

Figure 5 Standard denture with selected points and segments for measurements.

layer of approximately 3 mm of silicone rubber (Zetalabor), and then the flask was filled with dental stone.

Wax elimination

The standardized wax elimination technique[9] was used for the Gypwater and Silwater groups. The metal flasks were placed in boiling water for 3 to 5 minutes to soften the wax, then they were opened and the wax completely eliminated with a toothbrush, detergent, and boiling water. Next, the flasks were left open to eliminate excess moisture and to cool. After cooling and drying, all the surfaces of exposed gypsum were isolated with a sodium alginate solution (Cel Lac, SS White, Rio de Janeiro, Brazil).

In the Gypmicro and Silmicro groups, wax was eliminated using a microwave oven (Sanyo, Manufacturer assembled in the Amazon, 800 watts), according to the acrylic resin manufacturer's instructions. The microwave oven may be set at power levels ranging from 1 to 10. The flasks were closed, screwed together, and placed in the microwave oven for 2 minutes at 800 W at power level 8 for the initial wax elimination. Flasks were then opened to eliminate wax residues, using a toothbrush, detergent, and warm water. A cotton ball covering all the teeth was inserted inside the flask, which was closed and placed in the microwave for 1 minute at 800 W at maximum (level 10) power. The procedure was repeated a second time, the cotton ball removed, and the flasks were then left open to eliminate excess moisture and to cool.

Acrylic resin packing and polymerization

Control and Silwater groups were packed using an acrylic resin (QC20, Dentsply Ind Com), and trial packed twice using polyethylene sheets (Coopercel, Cooperativa Trab. I.M. Embalagens, Sao Paulo, Brazil) as separator. The first trial packing was done under 500 Kg/f hydraulic pressure to attain metal-to-metal contact and eliminate the resin excess. Then the flask was opened, the resin excess was eliminated, and the flask was slowly re-packed under 1000 Kg/f hydraulic pressure. The flask was left on the bench under pressure for 1 hour, and then the acrylic resin was polymerized in a boiling water bath for 20 minutes.

In the Gypmicro and Silmicro groups, the specimens were packed as described above using the acrylic resin designed for use with microwave oven polymerization, and polymerized as follows: (1) 3 minutes in microwave oven at power level 4, (2) 4-minute rest, and (3) 3 minutes in microwave at power level 9. Once polymerization was complete, the flasks remained on the bench until completely cooled, and then were opened to measure the polymerized dentures.

Data analysis

Data were organized in tables and analyzed by statistical analysis software (SAS 8.0; SAS Institute Inc., Cary, NC). The difference was calculated between the measurements of waxed and polymierzed dentures for six tooth position segments. Positive values imply shrinkage, and negative values imply expansion of artificial tooth positions. For each segment, differences were statistically compared by univariate ANOVA at 5% significance, and Tukey post-hoc test was used to determine significant differences between groups.

Results

The average tooth positional change values and the standard deviation for each segment in the trial and polymerized denture for the control and experimental groups are shown in Table 1. In addition, the percentage of these changes is presented in Table 2.

In terms of percentage, the Silmicro group showed the least tooth positional changes for all segments, whereas the greatest

Table 1 Tooth positional change mean values and standard deviation (cm) between waxed and polymerized stages for control (Gypwater) and experimental groups

Segments \ Group	Gypwater	SD	Gypmicro	SD	Silwater	SD	Silmicro	SD
A	0.049	0.039	0.036	0.043	0.015	0.058	−0.005	0.045
B	0.054	0.049	0.037	0.052	0.022	0.065	−0.013	0.042
C	0.041	0.039	0.030	0.044	0.016	0.043	−0.004	0.027
D	0.044	0.031	0.026	0.029	0.014	0.041	−0.004*	0.032
E	0.022	0.036	0.018	0.034	0.018	0.049	−0.004	0.039
F	0.048	0.056	0.034	0.051	0.020	0.058	−0.002	0.045

*Statistically significant difference was observed only between Silmicro and Gypwater group in segment D ($p < 0.05$). Positive values imply shrinkage, and negative values imply expansion of artificial tooth positions.

degree of changes was shown in the control (Gypwater) group. The percentage of changes ranged from −0.04% for segment F to −0.031% for segment B and from 0.80% for segment E to 1.36% for segment C, in Silmicro and the control group, respectively. Although differences were observed, they were not statistically significant, except for the changes that occurred in segment D (Tables 3 and 4) of the Silmicro group (-0.004 ± 0.032 cm) in comparison to the Gypwater (control) group (0.044 ± 0.031 cm).

Discussion

In this study, a significant difference was found only in one segment of the Silmicro group compared with the control group. This was probably due to the greater expansion of this segment in the Silmicro group in comparison to greater shrinkage of the same section in the control group. The greater distortion magnitude may be explained by the greater acrylic resin base thickness found in the buccal region of the denture;[24] however, this variable was not within the scope of this study. Therefore, future studies may be necessary for better understanding of the behavior and direction of these changes. Significant differences in the occlusal changes were also observed by Marcroft et al,[4] Reisbick,[6] and Zakhari.[7] The probable explanation for the superiority of silicone cap is that this material presents greater flexibility, and this physical property allows the stresses released during gypsum setting to be absorbed, so that smaller amounts of tooth positional changes are generated. Yet the same flexibility is indicated as a disadvantage, as it may allow the artificial teeth to move under excessive pressure during resin packing.[5,10] It should be emphasized that the packing process should be performed slowly and under proper amounts of pressure to provide suitable resin flow. The data in the present study also corroborated previous studies[5,8,10,14] that found no statistical difference in tooth positional changes or denture adaptation when silicone and gypsum cap layers were compared. This situation was most likely due to the high standard deviation presented by the experimental group specimens flasked with a silicone layer when compared with the mean change values. Although different results may be observed, it seems that silicone may be advantageous compared to gypsum as a cap layer material.

In the present study, when microwave polymerization was compared with water bath polymerization, no significant difference was found between the two techniques, and the average change values of the specimens polymerized by microwave energy were even slightly lower. These findings are in accordance with previous studies[11,15,16,23] that reported no evidence of dimensional change difference between the two techniques. In terms of percentage, a similar change in the inter-molar width (segment A in this study) was found by Keenan et al[16] when microwave was used for polymerization. The similarity in tooth positional changes observed between water bath and microwave polymerization techniques is not supported by other authors.[12,13] The discrepancies observed among the results may be attributed to the differences in the acrylic resins, the wattage of the microwave, and the polymerization cycle. The influence of these factors on the behavior of artificial tooth positional

Table 2 Difference in percentage between averages of waxed models, before and after polymerization for each technique

Segment \ Group	Gypwater	Gypmicro	Silwater	Silmicro
A	1.12%	0.82%	0.35%	−0.13%
B	1.22%	0.83%	0.52%	−0.31%
C	1.36%	1.02%	0.54%	−0.12%
D	1.21%	0.71%	0.37%	−0.10%
E	0.80%	0.66%	0.65%	−0.13%
F	1.12%	0.80%	0.49%	−0.04%

Table 3 Univariate ANOVA test for segment D

	Sum of squares	Degrees of freedom	Mean square	F	P
Intercept	0.016	1	0.01600	14.43386	0.000539
Group	0.012229	3	0.004076	3.67722	0.020796*
Error	0.039906	36	0.001109		

*Statistically significant difference with sigma-restricted parameterization at 5%.

Table 4 Tukey post-hoc test to determine differences between groups

	Gypwater (0.044)	Gypmicro (0.026)	Silwater (0.014)	Silmicro (−0.004)
Gypwater		0.608785	0.184945	0.014044*
Gypmicro	0.608785		0.841488	0.214225
Silwater	0.184945	0.841488		0.659266
Silmicro	0.014044*	0.214225	0.659266	

*Statistically different at 5% significance.

changes is still unclear. The Silmicro group was found to have the smallest positional changes. This result was probably to be expected, because in this group, both the flasking and polymerization technique alone would provide improved processing accuracy in relation to the conventional technique of denture processing. The use of silicone would offer less dimensional change due to its greater flexibility; and the microwave energy would generate heat inside the resin, one factor to promote homogeneity in the polymerization.[20]

Finally, it should be emphasized that other variables, such as the shrinkage or expansion of the resin and expansion of the gypsum during the processing, that could account for the positional changes of the teeth were not considered in the present study.

Conclusion

Within the limitations of this study, it was concluded that all the processing techniques for complete dentures tested resulted in positional changes of artificial teeth although in different magnitudes. Although the use of silicone layer for flasking provided a general decrease in tooth positional changes, a statistically significant difference ($p < 0.05$) of the dimensional changes was observed only for segment D, the distance between the second premolars, when Silmicro group was compared to the control group. The microwave energy polymerization technique showed a minor degree of tooth positional changes, shrinkage, or expansion, when compared with the water bath conventional polymerization technique, but these improvements were not statistically significant.

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