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Changes in denture teeth location in three different flasking techniques

Ahmed Asim Al-Ali, Abdullah Jasim Mohammed, Omar Abdul Mohsin Sheet
Department of Prosthodontics, College of Dentistry, University of Mosul, Mosul, Iraq

ABSTRACT

Background: *Artificial tooth movement may compromise the occlusion of complete (or implant-supported complete) over-dentures. This movement can lead to traumatic occlusion that may need to be corrected because the planned harmonious occlusion is lost, mainly when anatomic artificial teeth are utilized.* ***Purpose:*** *The study was conducted to evaluate the effect of the combination of gypsum plaster and laboratory silicon on the artificial teeth movement during the flasking procedure using radiographic imaging of intra-flask changes.* ***Methods:*** *In the current study, 90 identical mandibular complete dentures were fabricated and divided into two groups according to the acrylic material used. Stainless-steel pieces (0.50.5) were placed in the (buccal and mesiobuccal) cusp tips of the first premolar and first molar on both sides. Each group was subdivided into three subgroups (n=15) representing different techniques of flasking. Radiographs were taken at three phases of the flasking procedure, before and after the second investment layer and after curing the acrylic. The anteroposterior and mediolateral factors were calculated, and the data were analyzed by the one-way analysis of variance (ANOVA) and Duncan's post hoc tests at P<0.05.* ***Results:*** *The anteroposterior factors of the groups had insignificant differences at all phases, and the mediolateral factors showed significant differences in the gypsum samples and total silicon samples.* ***Conclusion:*** *Anteroposterior movement of the artificial teeth was not changed due to bracing between the teeth, and a mixed silicon and plaster investing layer had the smallest teeth location changes during the packing and curing phases.*

Keywords: *artificial teeth; complete denture; investing method; medicine; tooth movement*
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Correspondence: Abdullah Jasim Mohammed, Department of Prosthodontics, College of Dentistry, University of Mosul, Mosul, Iraq. Email: abdoalla2009@uomosul.edu.iq

INTRODUCTION

The success of full dentures depends on keeping the artificial teeth in their vertical and lateral locations while they are being made.[1] However, because of the intricate processes and use of heat during denture manufacture, the acrylic denture foundation might experience dimensional alterations.[2,3] This deformation may cause teeth to migrate laterally and vertically, reducing the vertical dimension of the occlusion.[4–6] Balanced occlusion of the artificial teeth is essential for complete dentures' retention and stability, particularly in patients with serious alveolar bone resorption.[7–9] Dentures may need to be redone if excessive tooth motions caused by manufacturing affect the occlusion, aesthetics, and shape.[10]

Previous research emphasized the involvement of investing materials in these dimensional alterations, in addition to other aspects, including the manner of flask closure, the deflasking process, and the thickness of the acrylic denture foundation.[4,11] The second pour of the plaster incorporating gypsum into the flask expands and can dislodge the teeth from their intended position. Some studies have found that this expansion can result in artificial teeth being shifted from their intended position.[6,10,12] Gypsum products and laboratory silicone are utilized separately or combined as investment materials. Due to their excellent effectiveness in decreasing finishing and polishing operations, laboratory silicones can be used in place of or combined with gypsum compounds.[4,13,14]

Prior studies focused on factors such as post-polymerization changes, methods of deflasking, and flasking procedures on the change of teeth position.[3,4,15,16] However, no studies aimed to find the phase of investment material inside the flask that would cause these changes.

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For this reason, the objective of this study was to estimate the effect of a second investing layer composed of a mixture of laboratory silicon and plaster on the positional changes of the denture teeth in three phases of the flasking procedure (before the placement of the second investment layer that surrounds the wax denture, after the placement of the second layer, and after curing) using a radiographic imaging technique. The current study hypothesized that utilizing a second layer of a mixture of laboratory silicon and plaster would reduce the position changes of the artificial teeth inside the flask.

MATERIALS AND METHODS

Ninety ideal lower master casts were fabricated using an Elite rock die stone (Zhermach Co., Italy) with edentulous ridge rubber molds with similar dimensions and anatomy. On one cast, a set of lower acrylic teeth (Samed Ultra-Plus, Dentaş Dental Industry, Turkey) was arranged at the crest of the cast ridge 18mm from the incisal ridge to the deepest point in the sulcus in the anterior region and 12mm from the mesiobuccal cusp of the first molar to the deepest point in the sulcus at the posterior region. The wax part was polished in one plane without festooning as the arrangement was made. The wax denture was duplicated with heavy body impression silicon (c-silicon, Ormadent, Major Co., Torino, Italy).[14]

The acrylic teeth with similar anatomy and size were arranged inside the heavy body silicon impression material mold. A modeling wax was melted and poured inside the mold, and a fully edentulous cast was replaced inside the mold. This procedure produced 90 identical wax dentures built on the gypsum casts. Cavities (0.5mm diameter and 0.5mm depth) were prepared at the first premolar's buccal cusp and the second molar's mesiobuccal cusp. The tip of the cusps was used in the current study because the teeth may roll around their axis with no evidence in the radiographic images when the pins are located in the central area of the occlusal plane. Cavities were created by using a surveyor milling machine (1000 MAX milling machine, Bio-art, Brazil) at the zero-tilt inclination that was calibrated by a digital inclinometer (smart mini digital level inclinometer 35908TE, MPJA Inc., USA). Stainless-steel pins of the same dimensions were fixed inside these cavities using commercial adhesive and trimmed to the cusps surfaces as illustrated in Figure 1A.[15] Plaster of Paris (Alçıbay Adhesive Plaster, Alçıbay Co., Turkey) was used to fill the lower division of a monomaxillary flask to the level of the wax denture flanges as a layer for the lower half of the flask. A piece of stainless steel 10mm in length was immersed in the first investing layer, as shown in Figure 1B, to calibrate the virtual image changes from radiographs to the virtual version and the importing of the image to the AutoCAD program. At this point, the samples were divided into two main groups (n=45 for each group) according to the heat cure acrylic resin of two companies used in the current study (Veracril, New Stetic Co., Colombia, and Procryla, President Dental GmbH, Allershausen, Germany). Each group was divided into three subgroups according to the second investment layer used (full laboratory silicon, full plaster, and mixed silicon and plaster). Each subgroup was subjected to a radiographic session at three phases of the flasking and packing procedure (before placement of the second layer as control readings, after setting the second layer, and after packing and curing the resin).

Each subgroup (n=15) was subjected to a radiographic examination (as a non-destructive examination method) using a dental radiographic machine (Planmeca, Helsinki, Finland), where the upper and lower flask parts were reassembled, and the upper and lower metallic caps of the flask were removed to allow the penetration of the X-ray into the examined investing materials inside the flasks. Occlusal radiographic films (Kodak Co., USA), with the source radiograph, were constantly fixed at 90º using the digital inclinometer and fixed at a distance (10cm) from the upper edge of the flask each time. The radiograph exposure parameters were set at 70Kvp and 72mAs values. The stainless-steel pins as they appear in the radiographs are shown in Figure 2A.

Thirty samples (15 samples for each intended company) were selected to be invested by full silicon second layer investment, where the upper part was filled with laboratory silicon (Zetalabor, Zhermack Co., Badia Polesine, Italy). After 24 hours, the silicon investment was set, the upper and lower caps were removed to allow the X-ray penetration through the flask, and a radiographic session was performed according to the abovementioned parameters. Thirty samples (n=15) for each company were invested with a full layer of plaster gypsum material as an upper investing layer. After 24 hours, the plaster set and the upper and lower caps were removed, and a radiographic session was performed according to the same parameters.

Thirty samples (n=15) for each company were invested by a layer composed of laboratory silicon attached to the wax denture to the level of the cervical lines of the artificial teeth with a 3–4mm thickness, and the silicon material allowed to set. One hour later, the upper half of the flask was reassembled, and the remaining space was filled with plaster material. The combination was allowed to be set for 24 hours. Then, the upper and lower caps of the flask were removed, and a second radiographic session was performed.

After the second radiographic session, the ninety samples were dewaxed with a hot water bath, and each of the three subgroup sets (full silicon, full plaster, and mixed silicon-plaster) was packed with Procryla heat cure resin. The other three subgroups were packed using Veracril heat cure resin material. The samples were then subjected to a packing pressure (10Kg/Cm^2) and immersed in a 100ºC water bath according to the manufacturer's instructions. The cured flasked dentures were allowed to bench cool, and a third radiographic session using the parameters mentioned above was performed for each subgroup.

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The occlusal radiographs taken were scanned to convert the images to digital form. An AutoCAD 2017 program was used to measure the linear distances between the radio-opaque stainless-steel pins from the farthest point at the pin's periphery to the other and calibrated using the stainless-steel piece immersed in the first investing layer, as shown in Figure 2B, where the original length of the stainless-steel piece was divided by the virtual length multiplied by the virtual length of the factor (anteroposterior or mediolateral) to find the absolute length of the factor. The measurements were set to millimeters (at 0.000mm precision) on the worksheet. The premolar-molar distance measured on the right and left sides of the numbers gathered was subjected to the following equation to calculate the anteroposterior factor:

Anteroposterior factor = Right (PM+ Left PM)/2

Where PM is the premolar-molar distance.

The premolar-premolar and molar-molar distances were measured, and the gathered numbers were used to calculate the mediolateral factor according to the following equation:

Mediolateral factor = (PP+MM)/2

Where PP is the premolar-to-premolar distance, and MM is the molar-to-molar distance.

A comparison between the effects of heat-cured acrylic shrinkage of the two companies was conducted by comparing the third stage (after curing) factors in both directions (anteroposterior and mediolateral). The current experimental study was conducted in the research laboratory in the department of prosthodontics in the College of Dentistry/University of Mosul, under the approval of the Research Ethics Committee College of Dentistry/University of Mosul code: UoM.Dent.23/45, from January–July 2023. Statistical analyses were performed using the SPSS 17 program (SPSS Inc., Chicago, IL, USA). ANOVA and Duncan's multiple range tests were used to find the statistical mean and significance for the data collected at a significance level of $P < 0.05$.

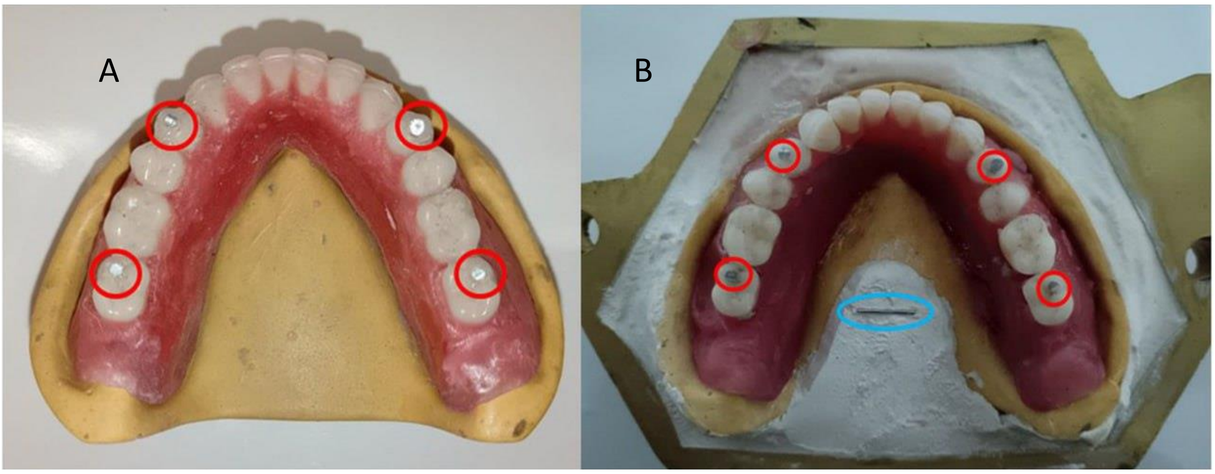

Figure 1. Image A shows the waxed lower denture with the metallic pins encircled with red. Image B shows the flasked wax denture with the metallic pins encircled with red and the calibrating piece with a blue circle.

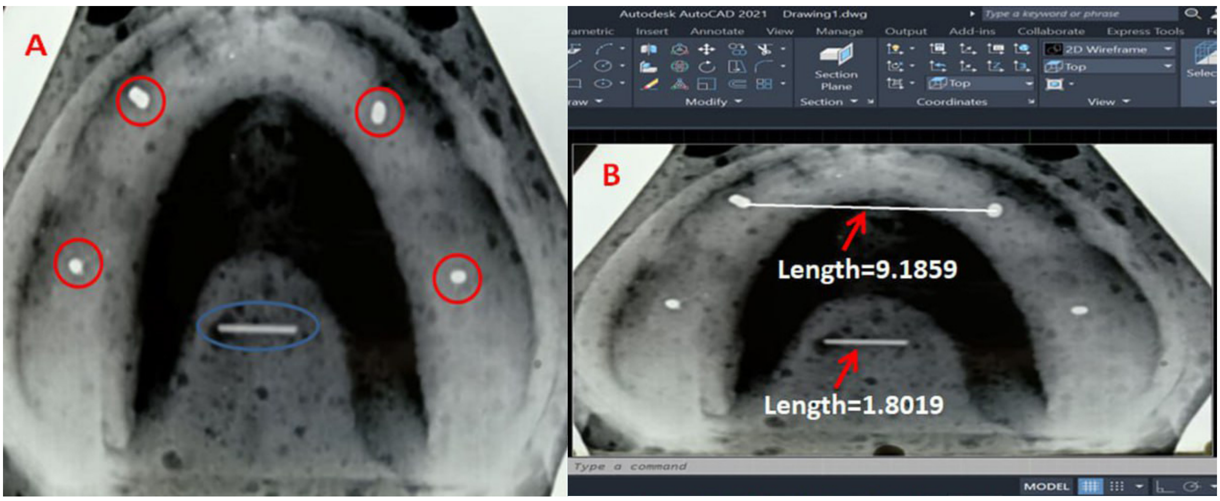

Figure 2. Image A shows the radiographic image of the flask with the metallic pins with red circles and the calibrating piece with a blue circle. Image B the AutoCAD measurements and calibration of the distance factor.

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RESULTS

In the current study, the anteroposterior and mediolateral factors were evaluated using a radiographic image of the intra-flask changes at three stages of the flasking and packing procedure (before the placement of the second layer as the reference phase, after the setting of the second layer as the second phase, and after packing and curing the resin as the third phase). The statistical evaluations of the anteroposterior distance factors were accomplished independently with ANOVA and Duncan's multiple range tests for each subgroup at the three stages of the flasking procedure. All subgroups showed insignificant statistical differences among the three phases of the flasking and packing process, as shown in Table 1.

The statistical analyses of the mediolateral distance factors were conducted using ANOVA and Duncan's multiple range tests, as shown in Table 2. In the first subgroup, where a complete layer of silicon was used, tests revealed that in both main groups, the mediolateral factor mean of the first group packed with acrylic resin (Procryla resin material) showed a significant increase in the third phase of the flasking procedure (36.999±.3567) when compared to the reference phase and the second phase (35.110±.1297 and 35.175±.2021), respectively. The mediolateral factor mean of the second group packed with acrylic resin (Veracril resin material) showed a significant increase in the third phase of the flasking procedure (36.911±4313) when compared to the reference phase and the second phase (35.127±.1315 and 35.183±.5314), respectively. In the second subgroup set, where a complete layer of plaster was used, tests revealed that the mediolateral factor mean of the first group packed with acrylic resin (Procryla resin material) showed a significant increase in the second and third phases of the flasking procedure (36.244±.3788 and 36.154±.2584), respectively, when compared to the reference phase (35.100±.1037), and the mediolateral factor mean of the second group packed with acrylic resin (Veracril resin material) showed a significant increase in the second and third phase of the flasking procedure (36.125±.2914 and 36.124±1690), respectively, when compared to the reference phase (35.139±.1433). The mediolateral distance factor of the third subgroup, where the second investing layer was composed of combined laboratory silicon and plaster materials and made from Procryla resin material,

Table 1. Mean and standard deviation of the anteroposterior factor for both companies and the three investing techniques.

			Anteroposterior factor mean ±SD		
Company	Flasking method	N	Before 2nd layer	After 2nd layer	After curing
Procryla	C-S	15	16.202±.0377*	16.221±.0488*	16.146±.0333*
	C-P	15	16.120±.0362*	16.200±.0424*	16.232±.0365*
	S-P mixed	15	16.185±.2596*	16.317±.1973*	16.342±.3190*
Veracril	C-S	15	16.230±.1286*	16.321±.2396*	16.232±.1515*
	C-P	15	16.201±.1598*	16.162±.1604*	16.212±.1713*
	S-P mixed	15	16.167±.0357*	16.229±.0781*	16.338±.0700*

Where C-S is the complete silicon upper investing layer, C-P is the complete plaster upper investing layer, and S-P is the mixed silicon and plaster upper investing layer. SD is the standard deviation. Labeling with similar symbols indicates insignificant differences within the same row.

Table 2. Mean and standard deviation of the mediolateral factor for both companies and the three investing techniques.

			Mediolateral factor mean ±SD		
Company	Flasking method	N	Before 2nd layer	After 2nd layer	After curing
Procryla	C-S	15	35.110±.1297*	35.175±.2021*	36.999±.3567**
	C-P	15	35.100±.1037*	36.244±.3788**	36.154±.2584**
	S-P mixed	15	35.151±.0424*	35.123±.0332*	35.066±.1648*
Veracril	C-S	15	35.127±.1315*	35.183±.5314*	36.911±4313*
	C-P	15	35.139±.1433*	36.125±.2914**	36.124±.1690**
	S-P mixed	15	35.191±.1633*	35.296±.2780*	35.344±.3991*

Labeling with similar symbols indicates insignificant differences within the same row.

Table 3. Mean and standard deviation of the anteroposterior and mediolateral factors for both companies after the packing process of the lower complete dentures.

Shrinkage direction	Company	N	Factors mean ±SD		
			C-S	C-P	S-P mixed
Anteroposterior	Procryla	15	16.146±.1296*	16.221±.1412*	16.342±.3190*
	Veracril	15	16.232±.1515*	16.212±.1713*	16.338±.2713*
Mediolateral	Procryla	15	36.999±.3567**	36.154±.2584**	35.066±.6383**
	Veracril	15	36.911±.4313**	36.124±.1690**	35.344±.3991**

Labeling with similar symbols indicates insignificant differences within the table.

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showed insignificant differences among the three phases of the flasking procedure (35.151±.0424, 35.123±.0332, 35.066±.1648), orderly. The mediolateral distance factor of the third subgroup made from Veracril resin material showed insignificant differences among the three phases of the flasking procedure (35.191±.1633, 35.296±.2780, 35.344±.3991), orderly. One type of heat cure resin that was cured with one physical method (boiling water) was used in the current study to verify the effect of shrinkage of the acrylic resin between the two manufacturers.

The third processing phase values, where the resin material involved in the fabrication process was compared between the two companies, revealed insignificant statistical results differences among all subgroups at the three processing phases for both anteroposterior and mediolateral distance factors. These results are shown in Table 3.

DISCUSSION

The change in the position of the denture teeth during the intricate fabrication process has major concerns for the prosthodontics society, whether they are specialists, general practitioners, or laboratory technicians, where the fabrication of a complete denture with little or no occlusal modifications is needed to be done after the fabrication process. Teeth displacement during denture manufacture may be caused by various variables, including the pressure applied, the investing components and their expansion, the closure of the flask, and the dimensional stability of resin materials used in the fabrication procedure.[14,17] The current study focused on the investing materials and techniques and the behavior of these materials inside the flask by observing and measuring their changes instead of predicting what happens inside the closed flask. By predicting the behavioral changes in the investment layer, the laboratory workers can alleviate the effects of investing materials, which include expansion, contraction due to the exothermic setting, and determine the best method for flasking that best reduces these effects. Three sets of measurements of the anteroposterior and mediolateral factors were created. The first measurements were taken before the second pour (first phase of processing) and were the control or reference measurements for the subsequent two processing phases. Other measurements were taken after setting the second investing layer (second phase), and the third measurements were taken after the packing and curing procedures (third phase). Statistical analyses showed that the anteroposterior distance had insignificant differences in the groups, while the mediolateral distance was changed in groups 1 and 2 and insignificantly in group 3. Thus, the hypothesis was proved according to the results of the current study. Statistical analyses of the anteroposterior distance factors showed insignificant differences among the subgroups, which indicates that the presence of adjacent teeth prohibited the movement of the artificial teeth in the anteroposterior direction because of the bracing effect on the contact areas among the artificial teeth.[15,16,18,19]

The statistical analyses of the mediolateral distance factors in samples constructed with a full silicon second investment layer showed a significant increase in the third phase of flasking, which involved packing, and the pressure of packing, and curing. This phase produced a lower compressive strength of silicon when compared to plaster of Paris. The hydraulic press generates approximately 3500psi, and this pressure was released by removing the flask from the clamp, which produced another phase of pressure on the full silicon layer that was not braced with gypsum material, leading to irreversible alterations in the second investing layer.[4,17,20] Statistical analyses of the second subgroup set for both manufacturers, in which a full layer of plaster of Paris was utilized, revealed that the changes in the mediolateral teeth position were significantly higher in the second and third phases of fabrication, indicating that these changes took place immediately after setting the second layer, the investing plaster, indicating that these changes could have been the result of the expansion of the gypsum materials.[21,22] Alternatively, they could have been the result of an exothermic reaction during the setting reaction of the plaster that may have contributed to the changes in the wax denture base, and subsequently, the location of the artificial teeth. These results support previous studies' results, which stated that the temperature of the plaster setting reaction could reach 45ºC and that such a temperature could result in wax surface alterations inside the flask, subsequently changing the location of the artificial teeth.[4,15,20] The changes in the second type of investment were also insignificant between the second and third processing phases, which provides a clue that the gypsum materials could withstand the pressure of the packing procedure during the denture construction.[15,21,23]

In the third subgroup for the two manufacturers, the laboratory silicon was attached to the wax denture base from the buccal and lingual aspects of the teeth to the level middle third of the artificial teeth at the buccal and the lingual sides, where, the silicon layer thickness was 3-4 mm and the rest of the upper half of the flask was filled with plaster gypsum product. Statistical analyses showed that the changes in this subgroup were insignificant for both manufacturers. The results suggest that the laboratory silicon insulated the wax denture base from expansion and the exothermic reaction of the plaster and utilized the higher compressive strength of the plaster in supporting the uncovered part of the artificial teeth. These results are consistent with other studies, which stated that the silicon layer interspersed between the wax and plaster had the smallest changes in teeth location.[17,24] These results contradict the findings of Becker et al. (1977), who found that no investing technique is superior in maintaining denture teeth location.[25] For comparing the extent of the effect of heat cure resin from two origins, the third phase means of both companies and directions were analyzed statistically and revealed insignificant differences among all subgroups fabricated with the two types of heat

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cure resin, indicating that there were no differences in the contraction of the two materials that were cured by the same physical method.[16,20,21,26]

The analyses of the six subgroups showed a lateral direction of movement, indicating that this movement was in the opposite direction to the higher mass of investing material rather than in a fixed pattern. These results are inconsistent with the suggestions of a previously conducted study, which were that the alterations in denture artificial teeth follow one pattern and always tend to move in a medial direction,[25,27,28] and concur with another study that suggested that the direction of movement follows an undefined pattern rather than a defined one.[4,15,27,28] The current study was limited by the use of monomaxillary flasks rather than double flasks, where only the mandibular dentures were used. This study was also limited by the use of one type of acrylic denture base, which depends on boiling water to cure it, rather than using other types of acrylic denture bases, such as those made of microwave or light-cured acrylic resin. For this reason, it is suggested that further studies be conducted to evaluate the use of more than one type of flask and acrylic resin material and that the current results be applied clinically.

From the current study, it can be concluded that the X-ray radiographic images were effectively utilized to find the phase at which the changes in the occlusal arrangement of the artificial teeth occur by measuring the distances between the metallic pins located in the first premolar and the second molar. Anteroposterior distance measurements revealed insignificant changes due to the bracing effect between the artificial teeth. Mediolateral distance measurements revealed that the occlusal changes of the artificial teeth are multifactorial and can occur at different phases of the flasking and packing procedures. These changes exist as a result of the material used as a second investing layer and its setting reactions. With the second layer composed entirely of laboratory silicon, the variations in teeth location were substantial due to the increased thickness of the silicon layer, which could decrease its compressive strength and result in lower resistance to the hydraulic pressure used during the packing process. Due to the setting (expansion and heat release), the plaster impacted the wax around the denture teeth (this effect started at the flasking stage). Therefore, alterations in tooth position can be reduced by separating the gypsum materials from the wax with a layer of laboratory silicon dough. The shrinkage of the two companies' resin materials cured by boiling water did not change the position of the teeth.

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