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Effect of Investment Material and Water Immersion Time on Tooth Movement in Complete Denture

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Abstract *- This study verified the effect of the association gypsum or silicone investment support materials and water immersion on the relative tooth movement in complete dentures. Wax record bases with teeth were assigned to 2 groups (n=10): 1- type III dental stone (control), and 2- condensation silicone. Linear distances (mm) between teeth were recorded after deflasking and after water storage for 1 week, 1 month and 3 months. With the exception of the silicone for the pre-molar distance after water storage for 3 months, the association between the type of investment and period of water storage did not alter the distances between teeth.*

KEY WORDS: Investment material, Tooth movement, Complete dentures, Deflasking, Water storage.

INTRODUCTION

The intimate fit between the denture base and the supporting mucosa is especially important for retention and stability of the denture. The procedures for fabrication of complete dentures require several clinical and laboratory phases, which may affect the definitive result. Some of such phases are: physical properties of the materials involved[1–3] and also the embedding processes[4].

Dimensional changes in the acrylic resin base during processing could impair the base retention and functional efficiency of complete dentures. Clinically, dimensional changes in a denture base may cause tooth displacement, when compared to the distances measured before and after polymerization[5]. Polymerization shrinkage of the base causes lack of dimensional accuracy and is a disadvantage in fabricating complete dentures; however, it can be partially compensated for by water sorption[5–9].

According to the diffusion theory for assessment of the quantitative aspects of the kinetics of water sorption, the diffusion coefficient governs the rate of water sorption and the time necessary to reach equilibrium, which is also proportional to the specimen thickness[10,11]. This means that the denture should fit better after water sorption than immediately after processing[12]. Thus, thorough denture base wetting is important, because materials with different surface energies have variable degrees of wettability[13]. It has been shown that water uptake by dentures in clinical use occurs in the first 3 months, and that the resultant expansion partially compensates the polymerization shrinkage[14], when water balance and consequent dimensional stability of the denture base are often attained[15,16].

The utilization of silicone as investment support instead of gypsum has the advantage of being an easy procedure that facilitates deflasking[17]. It provides easy denture finishing, since it can be deflasked without the attachment to the acrylic resin observed for the gypsum, a common consequence in the traditional technique of embedding in gypsum. The dimensional stability of silicone is better than that of gypsum; however, silicone does not maintain the teeth as firmly attached as the gypsum investment support[18,19]. The purpose of this study was to determine the effect of the association between gypsum or silicone investment materials and water immersion after storage in water for 1 week, 1 month, and 3 months at temperature of 37°C on the tooth movement in complete maxillary dentures. The hypothesis to be tested is that the tooth displacements in complete maxillary dentures would be influenced by the association of the investment support materials and water storage factors.

MATERIAL AND METHODS

Type III dental stone (Herodent Soli–Rock) and condensation silicone (Zetalabor Titanium) were used as complete denture investment support. Thirty-three degree acrylic resin teeth (Biolux) were used. Clássico heat-cured acrylic resin (Dental Products Co) was used for fabrication of the maxillary complete denture. According to the manufacturer, the acrylic resin polymer is based on pre-polymerized spheres of polymethyl methacrylate, and the monomer consists of the unpolymerized copolymer of methyl methacrylate.

Twenty maxillary complete dentures were fabricated from identical stone casts simulating an arch without irregularities in the alveolar ridge walls. Wax record bases with 2mm thickness were made on the respective stone casts, and the occlusion of the wax rims measured 20mm in the labial segment and 10 mm at the second molar region. The maxillary stone casts were mounted in a semi-adjustable articulator (Gnatus) with the interocclusal wax rim ratio according to the teeth of a mandibular stone cast, with the following references: intercondylar distance in intermediate position, Bennett angle at 15 degrees, and condylar guidance at 30 degrees[20,21].

Before teeth arrangement, the wax record base was measured at different locations with a calliper to standardize

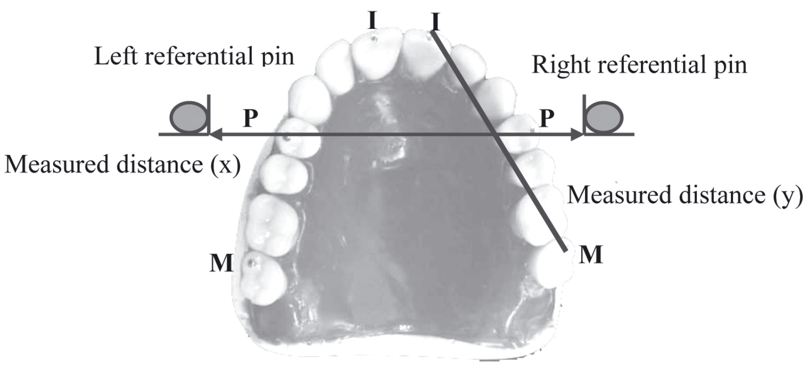

Figure 1. *Schematic drawing of the method for measurement of the x and y distances between teeth.*

the wax base at 2mm-thickness. The arrangement of the left central incisor served as a guide for positioning of the central and lateral incisors and canines. The same procedure was used for the right side of the arch. Arrangement of the posterior teeth was initiated by the first premolar up to the second molar. The same procedure was used for the right side. The tooth arrangement for interocclusal relationship was based on an anterior vertical overlap of 1mm.

Metal reference pins (Iara) with 1mm diameter were placed in the incisal border of the maxillary central incisors, buccal cusp of the first premolars, and mesiobuccal cusp of the second molars. The I-I (incisor to incisor), PM-PM (premolar to premolar), M-M (molar to molar) transverse distances, as well as the LI-LM (left incisor to left molar), and RI-RM (right incisor to right molar) anteroposterior distances were measured after denture deflasking and after water storage periods at 37°C for 1 week, 1 month and 3 months, using a micrometer (STM) with 0.0005–mm precision. Before each measurement, the ocular lens cross was adjusted to the vertical and horizontal internal border of the left referential pin. The digital register was set at zero for both x and z axes. The traveling table for measurement was moved until it touched the internal border of the right pin, establishing a linear trajectory in mm (*Figure 1*).

The maxillary denture on the stone cast was flasked in the minor half of a metallic flask (Safrany # 5.5) with type II stone (Star). The mixing ratio of distilled water and dental stone was 30mL:100gm. Petroleum jelly (Labsynth; Labsynth Chemical Products, Diadema, SP, Brazil) was used as a separating medium between the dental stone of the minor half of the flask and that used for the upper flask portion. The dentures were randomly assigned to 2 groups (n=10): group 1- type III dental stone investment (control); teeth were coated with a 3–mm thick dental stone portion (Herodent); group 2- condensation silicone; teeth were coated with a 3–mm thick Zetalabor Titanium silicone portion (Zhermack). The upper part of all flasks was invested with dental stone.

After 1 hour, the flasked dentures were placed in boiling water for 10 minutes to soften the base plate wax. The flask parts were separated, the wax was removed, the stone was cleaned with liquid detergent (ODD), and sodium alginate was used as a mold separator. The heat-cured acrylic resin was prepared in a mixing ratio of 35.5g polymer to 15mL monomer, according to the manufacturer's instructions**.** The bulk prepared was packed in the doughlike stage into the portion of the flask that houses the denture. A polyethylene sheet was placed over the acrylic resin, and the flask assembly was pressured. Initialy, the flask was pressured in a hydraulic press under a load of 850N. The flask assembly was separated, the polyethylene sheet was removed from the flask, and the flash was carefully removed from the surface of the mold. The flask assembly was once again placed in the press, and the final closure was under a load of 1,250N. The flask was transferred to a flask carrier, and the dentures were polymerized in a water bath at 74°C for 9 hours. The polymerization unit was set to raise the temperature to 74°C at 1 hour, and then keep this temperature for 8 hours. After the polymerizing cycle, the flasks were slowly cooled inside the water bath, and afterwards the denture was deflasked, polished, and placed to their corresponding original stone cast. The distances between teeth measured after deflasking were compared with the measurements after water storage at 37°C for 1 week, 1 month, and 3 months. Distillated water was used in the denture immersion procedure, and it was changed once a week. Under these conditions, each denture functioned as its own control. Data obtained in mm from the transverse and anteroposterior distances between teeth were submitted to the two-way ANOVA and Tukey test (α=0.05).

RESULTS

The ANOVA values presented in *Tables 1, 2, 3* and *4* did not reveal any statistically significant difference for the gypsum or silicone investments materials, or for the interaction between time and investment material. The ANOVA values presented in *Table 5* reveals statistically significant difference (p=0.0001) for the interaction between time and silicone investment material. The *Figures 2, 3, 4, 5* and *6* showed the means of the distances between teeth presented in the respective distances. *Table 6* shows the distances between teeth after deflasking and water storage for 1 week and 1 month, with no statistically significant difference. The 3-month period demonstrated statistical difference only for the PM-PM distance (α<0.05) for comparison between the investment materials and between periods for the silicone investment.

Table 1. *ANOVA for the I-I distance (mm) for gypsum or silicone investment materials and storage time, and investment and storage interaction.*

Variation	*DF*	*SS*	*MS*	*F value*	*P*
Embedding	1	1.1640400	1.1640400	8.1556	0.10534
Time	5	0.0294020	0.0058804	0.0412	0.99784
Embed x Time	5	50.0254742	0.0050948	0.0357	0.99826
Residue	108	15.4146764	0.1427285		
Total	119	16.6335927			

Overall mean 7.928667
Coef. Var. 4.765%

Table 2. *ANOVA for the M-M distance (mm) for gypsum or silicone investment materials and storage time, and investment and storage interaction.*

Variation	*DF*	*SS*	*MS*	*F value*	*P*
Embedding	1	1.5083679	1.5083679	2.7445	0.09653
Time	5	0.5468576	0.1093715	0.1990	0.96061
Embed x Time	5	0.1507687	0.0301537	0.0549	0.99657
Residue	108	59.35556560	0.5495894		
Total	119	61.5616502			

Overall mean 51.868332
Coef. Var. 1.429%

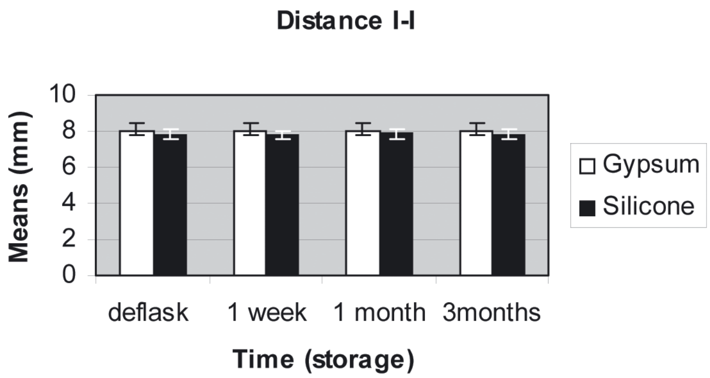

Figure 2. *Means of I-I distance (mm) in embeddings in gypsum or silicone investment materials in the periods of deflasking and storage in water for 1 week, 1 month, and 3 months.*

Table 3. *ANOVA for the RI-RM distance (mm) for gypsum or silicone investment materials and storage time, and investment and storage interaction.*

Variation	*DF*	*SS*	*MS*	*F value*	*P*
Embedding	1	0.2650948	0.2650948	0.6519	0.57326
Time	5	0.1927467	0.0385493	0.0948	0.99088
Embed x Time	5	0.1917454	0.0383491	0.0943	0.99097
Residue	108	43.9153854	0.4066239		
Total	119	44.5649723			

Overall mean 41.786415
Coef. Var. 1.526%

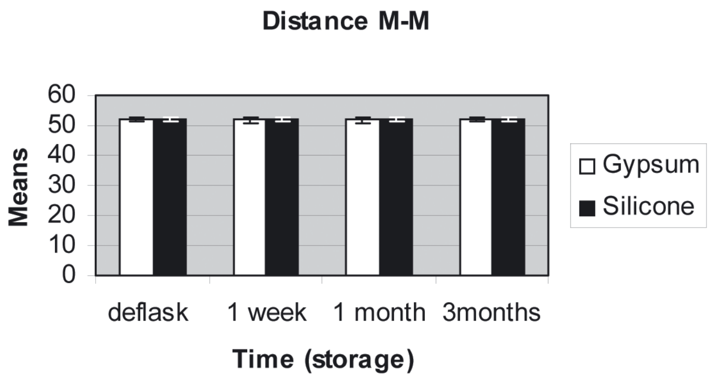

Figure 3. *Means of M-M distance (mm) in embeddings in gypsum or silicone investment materials in the periods of deflasking and storage in water for 1 week, 1 month, and 3 months.*

Table 4. *ANOVA for the LI-LM distance (mm) for gypsum or silicone investment materials and storage time, and investment and storage interaction.*

Variation	DF	SS	MS	F value	P
Embedding	1	0.0095492	0.0095492	0.0152	0.89771
Time	5	0.2995503	0.0599101	0.0954	0.99078
Embed x Time	5	0.2239430	0.0447886	0.0713	0.99460
Residue	108	67.8254267	0.6280132		
Total	119	68.3584692			

Overall mean 41.602501
Coef. Var. 1.905%

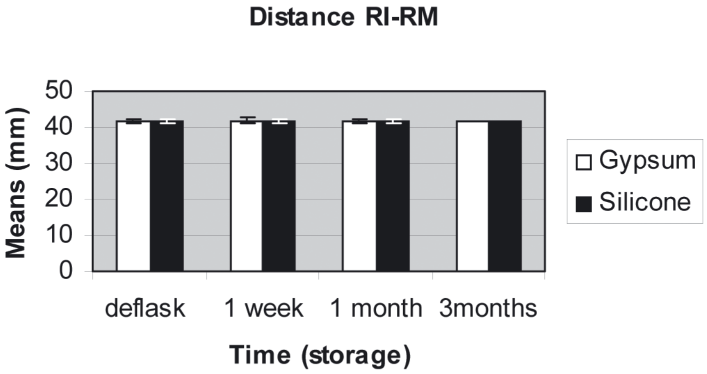

Figure 4. *Means of RI-RM distance (mm) in embeddings in gypsum or silicone investment materials in the periods of deflasking and storage in water for 1 week, 1 month, and 3 months.*

Table 5. *ANOVA for the PM-PM distance (mm) for gypsum or silicone investment materials and storage time, and investment and storage interaction.*

Variation	DF	SS	MS	F value	P
Embedding	1	0.2499405	0.0499881	0.0716	0.99456
Time	5	0.8452841	0.1690568	0.2421	0.94171
Embed x Time	5	12.5190618	12.5190618	17.9310	0.00017
Residue	108	75.4032324	0.6981781		
Total	119	89.0175188			

Overall mean 39.723415
Coef. Var. 2.103%

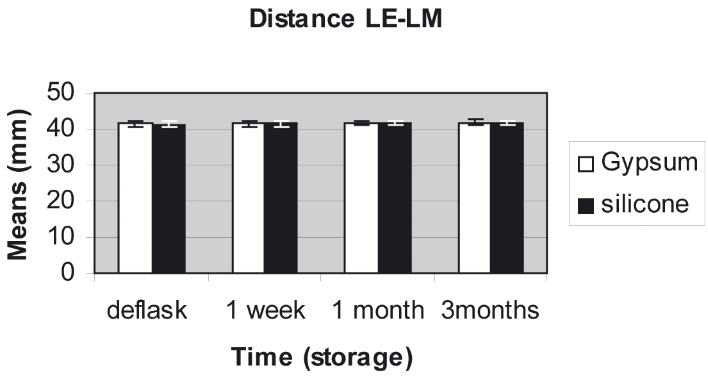

Figure 5. *Means of LI-LM distance (mm) in embeddings in gypsum or silicone investment materials in the periods of deflasking and storage in water for 1 week, 1 month, and 3 months.*

DISCUSSION

Water sorption is subject to the diffusion law, repelling the substrate macromolecules and increasing the material volume[6]. This fact may compensate for polymerization shrinkage of acrylic resins in the absence of the internal stresses induced during denture processing[6]. The effect of water sorption on tooth movement is difficult to evaluate, because several articles report divergent results[14,15,18,19]. An earlier investigation demonstrated that water sorption by resin bases occurs during clinical use and that the resulting dimensional changes may affect the denture occlusion[10].

According to previous studies[6,7,14,15,18], expansion occurs when the dentures were immersed in water, since water

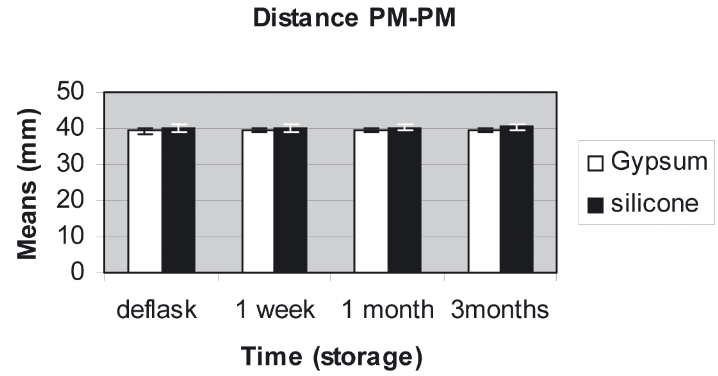

Figure 6. *Means of PM-PM distance (mm) in embeddings in gypsum or silicone investment materials in the periods of deflasking and storage in water for 1 week, 1 month, and 3 months.*

Table 6. *Tukey's test for the PM-PM distance (mm) for gypsum or silicone investment materials, deflasking and storage time.*

Storage	*PM-PM distance (mm)*	
	Gypsum	*Silicone*
Deflasking	39.34 ± 0.73 A, a	39.92 ± 0.98 A, a
1 week	39.38 ± 0.74 A, a	40.02 ± 0.88 A, a
1 month	39.45 ± 0.77 A, a	40.07 ± 0.90 A, a
3 months	39.46 ± 0.70 A, a	40.30 ± 0.87 B, b

Means followed by the same capital letters in the same column were not significantly different. Means followed by the same lower case letters in the same row were not significantly different by the Tukey test (α=.05).

sorption by acrylic resin is a well-established occurrence. In this study (*Table 6*), storage in water only promoted values with statistically significant difference for the PM-PM distance for comparison between the silicone and gypsum investment materials and water storage for 3 months, and when the periods were compared for the silicone investment material. This result is consistent with a previous study[11] showing that the remaining monomer in specimens after deflasking may affect the level of water sorption. Thus, dimensional changes by water sorption cause expansion, apparently because water enters between the PMMA molecules, resulting in a plasticizing effect[11], and is absorbed at different levels during polymerization or immersion in water[8]. This results did not agree with a previous report[19], which indicated no significant differences in the linear dimension of the acrylic resin specimens after water storage for up to 3 months.

In the present study, there was significant difference only at the PM region and water storage for 3 months, with no significant difference for the other measurements of distances between teeth. This result is supported by the work of Mahler[2], who reported that acrylic resin, at definitive closure of the flask, has sufficient internal shear resistance or viscosity to allow severe stress distribution in the unpolymerized denture. The result of this unequal stress condition is that some teeth shift more than others.

The results of the present study showed that the type of investment used for making the denture had little influence on tooth movement, considering that the linear measurements between teeth showed a statistically significant value only at the PM region and embedding in silicone. According to Perlowski[3], precise fit between the tooth and the investment material is more important than the hardness of the material used.

The measurement method involves the limitations concerning the relative distortion analysis, and it involves the measurements of the permanent displacement of the teeth in relation to a coordinate system, which moves with the referential metallic pins[22]. The total distortion between teeth distances was measured independent of the direction the reference pins were displaced. The complex system of concentration and release of stresses that causes tooth displacements are conjugated factors, which were not totally influenced by the water immersion periods.

Thus, the linear displacements were measured with a better level of accuracy than is commonly accepted for clinical relevance application. According to this study finding, the wettability of the acrylic resin base in intraoral use would not be sufficient to modify the distances between teeth.

With the exception of the PM-PM distance, the present study showed similar tooth movement for all storage periods, because there was a similar amount of water uptake by mass volume at these regions[9]. An earlier study demonstrated that the teeth distance dimensional change occurs initially after deflasking, and it was influenced by the different parts of the measured distance[21]. Thus, tooth movement occurring in the denture following water immersion is not only caused by water sorption, but involves other factors occurring during denture fabrication, such as base thickness, geometrical palate form, flask closure pressure, flask cooling method, different stresses released in different parts of the denture, and mesiodistal tooth contact[20,12].

Conflicting results have also been reported on the investment materials. One study showed better results for the investment support with gypsum[12], and others claimed better results for the investment with silicone[2,17]. In the present study, there was evidence of similar water sorption, since there was statistically significant difference only for the PM-PM distance with embedding in silicone and water storage for 3 months. During denture fabrication, there was greater stress concentration at the PM-PM region than in other measured distances, which were released during water storage, changing this distance when the denture was made with silicone investment material.

However, all methods to invest complete denture, which can definitely promote a minimal tooth displacement, are based in procedures to decrease the dimensional changes due to stress concentration in the flasking and stress releasing in the deflasking.

Within the limitations of this study in vitro, these results are relevant to confirm the tooth displacement showed in previous studies. Even thus, further studies are necessary to elucidate the influence of these investment materials on tooth movement**.**

CLINICAL RELEVANCE

The wettability of the denture in use would not be sufficient to change the distances between teeth stablished in the deflasking.

CONCLUSIONS

With the exception of the silicone investment material for the PM-PM distance after water storage for 3 months, the association between gypsum or silicone investment materials and water storage did not alter the distances between teeth.

MANUFACTURERS' DETAILS

- Herodent Soli–Rock; Vigodent, Ind. & Trade, Rio de Janeiro, Brazil; Batch 2445
- Zetalabor Titanium; Zhermack, Rovigo, Italy; Batch C972G
- Biolux; Dental Vipi Products, São Paulo, Brazil
- Clássico heat-cured acrylic resin, Dental Products Co, São Paulo, Brazil; Batch 903040
- Gnatus; Gnatus Medical & Dental Products, Ribeirão Preto, Brazil
- Iara, Ind. & Trade, São Paulo, SP, Brazil
- STM; Olympus Optical Co., Tokyo, Japan
- Safrany # 5.5; J. Safrany Metallurgy Co., São Paulo, Brazil
- Star; Chaves, Fortaleza, CE, Brazil
- ODD; Bombril-Cirio, São Paulo, Brazil

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REFERENCES

1. Arima, H., Murata, H. and Hamada, T. The effects of cross-linking on de water sorption and solubility characteristics of denture base resin. *J. Oral Rehabil.,* 1996; **23:**476–480.
2. Mahler, D.B. Inarticulation of complete dentures processed by the compression molding technique. *J. Prosthet. Dent.,* 1951; **1:**551–559.
3. Perlowski, A.S. Investment changes during flasking as a factor of complete denture malocclusion. *J. Prosthet. Dent.,* 1953; **3:** 479–497.
4. Woelfel, J.B. and Paffenbarger, G.C. Dimensional changes occurring in artificial dentures. *Int. Dent. J.,* 1959; **9:**451–460.
5. Skinner, E.W. Acrylic resins: an appraisal of their use in dentistry. *J. Am. Dent. Assoc.,* 1949; **39:**261–268.
6. Anusavice, K.J. *Philips' Science of dental materials.* 11th ed. Philadelphia (PE):W.B. Saunders; 2003. p. 738–744.
7. Skinner, E.W. and Cooper, E.M. Physical properties of denture resin: Part I. Curing shrinkage and water sorption. *J. Am. Dent. Assoc.,* 1949; **30:**1845–1852.
8. Teraoka, F. and Takahashi, J. Controlled polymerization system for fabricating precise dentures. *J. Prosthet. Dent.,* 2000; **883:**514–520.
9. Wong, D.M.S., Cheng, L.Y.Y., Chow, T.W. and Clark, R.K.F. Effect of processing method on the dimensional accuracy and water sorption of acrylic resin dentures. *J. Prosthet. Dent.,* 1999; **81:**300–304.
10. Ristic, B. and Carr, L. Water sorption by denture acrylic resin and consequent changes in vertical dimension. *J. Prosthet. Dent.,* 1987; **58:**689–693.
11. Sadamori, S., Ishii, T. and Hamada, T. Influence of thickness on the linear dimensional change, warpage, and water uptake of a denture base resin. *Int. J. Prosthodont.,* 1997; **10:**35–43.
12. Dixon, D.L. and Breeding, L.C. Linear dimensional variability of three denture base resins after processing and in water storage. *J. Prosthet. Dent.,* 1992; **67:**196–200.
13. Zissis, A., Yannikakis, S., Jagger, R.G. and Waters, M.G.J. Wettability of denture materials. *Quintessence Int.,* 2001*;* **32:** 457–462.
14. Mowery, W.E., Burns, C.L., Dickson, G. and Sweeney, A.B. Dimensional stability of denture base resins. *J. Am. Dent. Assoc.,* 1958; **57:**345–353.
15. Sweeney, W.T. and Taylor, D.F. Dimensional changes in dental stone and plaster. *J. Dent. Res.,* 1950; **29:**749–755.
16. Marcroft, K.R., Tencate, R.L. and Hurst, W.W. Use of silicone rubber mold technique for processing. *J. Prosthet. Dent.,* 1961; **11:**657–664.
17. Reisbick, M.H. Silicone as a denture mold liner. *J. Prosthet. Dent.,* 1972; **26:**382–386.
18. Zani, D. and Vieira, D.F. A comparative study of as a separating medium for dentures processing. *J. Prosthet. Dent.,* 1979; **42:**386–391.
19. Mainieri, E.T., Boone, M.E. and Potter, R.H. Tooth movement and dimensional change of denture base materials using two investment methods. *J. Prosthet. Dent.,* 1980; **44:**368–373.
20. Consani, R.L.X., Mesquita, M.F., Sinhoreti, M.A.C. and Consani, S. Influence of the deflasking delay time on the displacement of maxilary denture teeth. *J. Appl. Oral Sci.,* 2003; **11:**332–336.
21. Zakhari, K.N. Relationship of investing medium to occlusal changes and vertical opening during denture construction. *J. Prosthet. Dent.,* 1976; **36:**501–509.
22. Nicholls, J.I. The measurement of distortion: Theorical considerations. *J. Prosthet. Dent.,* 1977; **37:**578–586.