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The Influence of Storage on Dimensional Changes in Maxillary Acrylic Denture Bases and the Effect on Tooth Displacement

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Abstract - *This study investigated the influence of both room temperature storage and water storage on tooth displacement in complete dentures. Thirty maxillary dentures were manufactured and processed using 3 different curing cycles; long, short conventional and microwaved. Distances between fixed points on teeth were measured and the dentures stored at room temperature for 24 weeks. After storage, the distances were measured again and the dentures then stored in water at 37°C for 24 weeks, when the distances were re-evaluated. Anteroposterior distances demonstrated contraction in all acrylic resins. Incisor-incisor (air = -8.5% and water = -7.0%) and molar-molar (room = -1.8% and water = -1.1%) distance changes were greater in the Onda-Cryl resin ($p<0.05$), whereas the premolar-premolar (room = -2.2% and water = -1.7%) distance was higher in the QC-20 resin ($p<0.05$).*

KEY WORDS: Complete denture, Room temperature, Water storage, Tooth movement.

INTRODUCTION

Acrylic resin presents several advantages including low cost, easy processing method, dimensional stability in the oral environment, adequate strength for chewing loads, satisfactory durability, low sorption of oral fluid, and minimal solubility[1]. Furthermore, the material also presents stability of colour and offers the possibility of pigmentation, allowing characterization and adequate aesthetic conditions[2-4].

Since the development of acrylic resin, however, several studies have reported some disadvantages attributed to the material, such as dimensional changes due to polymerisation and altered dimensional stability of the base, depending on the denture processing technique used[5-10].

Studies show that the dimensional changes are still causing inaccuracies in the adaptation of complete dentures due to other variables, such as pressure during the acrylic resin pressing[11], denture thickness and curing cycle[6], processing methods[12-14], commercial types of acrylic resin[15], and flask closure method[8,16,17]. In addition, these dimensional changes can also influence the position of the teeth in the denture base, under the influence of other different variables such as the flasking procedure[18], deflasking time[19], investment material type[20], flask closure and flask cooling methods[21], flask closure method and post-pressing time[22], causing an increase in the vertical dimension of occlusion[5].

Classic studies have sought to associate packing with processing of the denture base resins[23], and have also evaluated denture bases when processed by different techniques[24]. As a result, alternative polymerisation techniques have been developed, including microwave energy[25], dry heat[26], fast cycle in boiling water[27] and visible light[12], aiming to improve the denture conditions when compared with those obtained in the conventional cycle with hot water.

Reports in the literature have shown that the most effective polymerisation method is that in which the acrylic resin is polymerised in hot water in a long cycle[1, 28]. However, satisfactory results were obtained when the dentures were processed by microwave irradiation[13, 25, 29] or by boiling water in a fast cycle[27, 30].

Changes in the acrylic resin base are difficult to correct after the processing of the denture. However, small changes in position of the posterior teeth can be alleviated by clinical occlusal adjustment[6, 31, 32]. Increase in the vertical dimension of occlusion can cause occlusal misfit of 0.5 to 1.0 mm. Although the increase in vertical dimension of occlusion may seem severe, the amount of tooth displacement necessary to produce it is admittedly smaller. Thus, an increase in the vertical dimension of occlusion of 1.0 mm may be the result of a teeth displacement of 0.25 mm[11].

It is claimed that excessive load during pressing of the acrylic resin and the different types of plaster used in the flask inclusion can also change the vertical dimension of dentures[33, 34]. However, the most important factor increasing the occlusal vertical dimension may be the amount of acrylic resin contained in the mould after the final pressing. Regardless of the strength of the force exerted by the hydraulic press, some excess of material remains in the mould, and the greater the excess, the greater the increase in the vertical opening of the prosthesis processed[35].

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Polymerisation shrinkage of the acrylic resin causes dimensional inaccuracy in the complete dentures, which can be partially compensated by the water sorption[1, 14, 36]. The resultant expansion, due to water uptake by dentures in oral use, occurs during the first 90 days[37], when the balance of the water sorption and dimensional stability of the denture base is attained[38]. For this reason, it is probable that the complete denture should present better adaptation and stability on oral tissues after water storage than after deflasking[39].

Considering the possibility that different types of storage can produce additional distortion in the complete dentures, the purpose of this study was to verify the effect of the room temperature and water storage on teeth displacement. The research hypothesis tested in this *in vitro* study was that different types of storage could adversely affect the teeth position in the denture base.

MATERIAL AND METHODS

Commercially-available acrylic resins (Classico and Onda-Cryl/Classico; and QC-20/Dentsply) were used to make maxillary complete dentures. The manufacturers state that Classico is a conventional acrylic resin based on a polymethyl methacrylate copolymer; Onda-Cryl is a microwave polymerised acrylic resin based on the methyl methacrylate and ethylene glycol methacrylate copolymer; and QC-20 is a boiling water-polymerised acrylic resin based on the methyl-n-butyl methacrylate, methyl methacrylate and ethylene glycol dimethacrylate copolymer. The plastic artificial tooth used was the Trubyte Biotone/Dentsply, model 3P and 32L (33 degrees), colour 62.

Thirty type III dental stone casts (Herodent) were used for complete denture processing, simulating an edentulous maxillary arch with normal alveolar ridge, with no retentions or acute irregularities. The wax base plate was prepared with a thickness of 2.0 mm[20], using two # 7 wax sheets (Epoxiglass), and the wax rim was made with 10 mm height in the posterior region and 20 mm in the anterior region.

The maxillary stone cast-wax base plate set was fixed in a Bio-Art semi-adjustable articulator, with intercondylar distance set to medium, Bennett angle of 15 degrees and condylar guidance at 30 degrees. A mandibular stone cast with teeth was related to the maxillary wax rim and attached to the frame of the articulator, maintaining the incisal guide pin at zero. The mounting of artificial teeth was performed by the conventional manner.

In order to measure the displacement of the tooth, reference metallic pins were fixed on the median region of the incisal border of the central incisors, buccal cusp of the first premolar and distobuccal cusp of the second molars. Holes were performed with a # ½ spherical bur (Maillefer) for fixation of the metallic pins (Iara) with instantaneous adhesive (Super Bonder).

The stone cast-wax base plates with teeth were randomly divided into three groups (n=10) and conventionally flasked in accordance to: 1- Classico resin pressing, metallic flask inclusion (Safrany) and water polymerisation at 74ºC for 9 h; 2- Onda-Cryl resin pressing, plastic flask inclusion (Classico) and microwave polymerisation in a domestic oven (Continental) with a potency of 1,100 watts and a cycle of 3 min at 28% of hull power, 4 min at 0% of full power, and 3 min at 65% of full power; and 3- QC-20 resin pressing, metallic flask inclusion and boiling water polymerisation for 20 min.

The acrylic resins were prepared using solutions in accordance with the manufacturer's instructions and flask pressed in a hydraulic press (Linea H) in the doughlike stage. A final pressing load of 1,250 kgf was used for the conventional and fast polymerised acrylic resins, whereas the microwaved resin was pressed under a load of 1,000 kgf.

After denture deflasking, the linear transverse measurements between the central incisors (I-I), first premolars (PM-PM) and second molars (M-M), and anteroposterior measurements between right incisor-right molar (RI-RM) and left incisor-left molar (LI-LM) were made with a comparator microscope (Olympus) with an accuracy of 0.0005 mm. For distance measurements, the optical reticule of the ocular lens was adjusted in the inner portion of the metallic reference pins[20] (Figure 1). The measurement after denture deflasking was considered as the control.

Afterwards, the dentures were stored in dry conditions in plastic containers at room temperature for 24 weeks. After the period of room temperature storage, the transverse and anteroposterior distances were measured again in the same manner. After these measurements, the dentures were stored in water in an oven at 37°C for 24 weeks, when the distances were re-evaluated again. The same operator made all the measurements.

Data obtained in the transverse and anteroposterior distances were submitted to 2-way ANOVA and Tukey's test at a 5% level of significance, considering the following factors: resin and storage, and interactions.

RESULTS

There were no statistically significant differences ($p>0.05$) among resins in the I-I distance, with the exception of the deflasked dentures (Table 1). At room temperature and water storage, Onda-Cryl resin presented the greatest changes, with significant difference ($p<0.05$) when compared to Classico and QC-20 resins, both without statistical difference between them ($p>0.05$). When each resin was analyzed in the storage periods, only Onda-Cryl showed statistical difference ($p<0.05$) when the deflasking was compared to room temperature and water storage (deflasking presented a higher value with statistically significant difference at $p<0.05$).

There was statistically significant difference among resins in the PM-PM distance only after deflasking, with a lower value for the Classico resin ($p<0.05$). In the comparison between storage periods, only the QC-20 resin presented statistical difference ($p<0.05$), where the value at deflasking was significantly greater than at room temperature (Table 2).

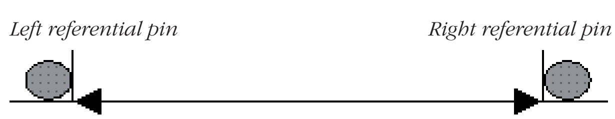

Figure 1. *Schematic drawing of the method for measurements.*

Table 1. *Mean I-I distance (mm) and SD according to original distances at deflasking, resins and storage periods (%).*

Resin	*Distance changes following deflasking and storage periods (%)*		
	Deflasking (original distance)	*Room temperature*	*Water storage*
Classico	7.47 (0.20) aA	7.50 (0.36) aA (+ 0.4%)	7.43 (0.30) aA (- 0.5%)
QC-20	7.44 (0.27) aA	7.39 (0.33) aA (- 0.6%)	7.56 (0.31) aA (+ 1.6%)
Onda-Cryl	7.35 (0.20) aA	6.72 (0.23) bB (- 8.5%)	6.83 (0.32) bB (- 7.0%)

Means followed by different lower case letters in each column and different capital letters in the same row differ significantly by Tukey's test (5%).

Table 2. *Mean PM-PM distance (mm) and SD according to original distances at deflasking, resins and storage periods (%).*

Resin	*Distance changes following deflasking and storage periods (%)*		
	Deflasking (original distance)	*Room temperature*	*Water storage*
Classico	38.07 (0.70) bA	38.33 (0.90) aA (+ 0.6%)	38.71 (0.71) aA (+ 1.6%)
QC-20	39.17 (0.76) aA	38.29 (0.62) aB (- 2.2%)	38.48 (0.65) aAB (- 1.7%)
Onda-Cryl	38.92 (0.86) aA	38.48 (0.43) aA (- 1.1%)	38.72 (0.43) aA (- 0.5%)

Means followed by different lower case letters in each column and different capital letters in the same row differ significantly by Tukey's test (5%).

Table 3. *Mean M-M distance (mm) and SD according to original distances at deflasking, resins and storage periods (%).*

Resin	*Distance changes following deflasking and storage periods (%)*		
	Deflasking (original distance)	*Room temperature*	*Water storage*
Classico	51.62 (0.79) aA	51.02 (0.85) aA (- 1.1%)	51.39 (0.63) aA (- 0.4%)
QC-20	51.32 (0.60) aA	50.53 (0.47) aB (- 1.5%)	50.93 (0.60) aAB (- 0.7%)
Onda-Cryl	51.54 (0.80) aA	50.59 (0.77) aB (- 1.8%)	50.95 (0.80) aAB (- 1.1%)

Means followed by different lower case letters in each column and different capital letters in the same row differ significantly by Tukey's test (5%).

Table 3 shows that the M-M distance was statistically similar among resins in all periods ($p>0.05$). When each resin was analyzed in each period, QC-20 and Onda-Cryl presented statistically different values when deflasking was compared to room temperature-stored dentures ($p<0.05$), whereas the values after water storage were similar to those shown in the other periods ($p>0.05$).

Statistically significant differences were observed among resins in the RI-RM distance only at room temperature ($p<0.05$), with the highest value for Onda-Cryl (Table 4). When each resin was analysed in the storage periods, Classico and QC-20 presented statistically higher values in the deflasking when compared to the values showed at room temperature and water storage ($p<0.05$). Onda-Cryl demonstrated statistical difference in all periods, with the lowest value for water storage and greatest after the deflasking period ($p<0.05$).

Table 4. *Mean RI-RM distance (mm) and SD according to original distances at deflasking, resins and storage periods (%).*

Resin	Distance changes following deflasking and storage periods (%)		
	Deflasking (original distance)	Room temperature	Water storage
Classico	41.57 (0.53) aA	37.20 (0.57) bB (- 10.5%)	37.44 (0.35) aB (- 9.9%)
QC-20	41.53 (0.52) aA	37.16 (0.41) bB (- 10.5%)	36.98 (0.36) aB (- 10.9%)
Onda-Cryl	41.78 (0.31) aA	38.26 (1.05) aB (- 8.4%)	37.05 (0.81) aC (- 11.3%)

Means followed by different lower case letters in each column and different capital letters in the same row differ significantly by Tukey's test (5%).

Table 5. *Mean LI-LM distance (mm) and SD according to original distances at deflasking, resins and storage periods (%).*

Resin	Distance changes following deflasking and storage periods (%)		
	Deflasking (original distance)	Room temperature	Water storage
Classico	40.90 (0.56) aA	32.43 (0.73) aB (- 20.7%)	32.83 (0.72) aB (- 19.7%)
QC-20	40.78 (0.54) aA	32.35 (0.51) aB (- 20.6%)	32.90 (0.40) aB (- 19.3%)
Onda-Cryl	40.83 (0.38) aA	31.49 (0.66) bC (- 22.8%)	32.42 (0.71) aB (- 20.5%)

Means followed by different lower case letters in each column and different capital letters in same row differ significantly by Tukey's test (5%).

Table 5 shows that there was statistically significant difference among resins in the LI-LM distance, only at room temperature, with the lowest value for Onda-Cryl ($p<0.05$). The Classico and QC-20 resins showed similar values ($p>0.05$). When each resin was analyzed in the different periods, Classico and QC-20 showed higher values following deflasking, with statistically significant difference when compared to room temperature and water storage ($p<0.05$). Onda-Cryl presented statistical difference in all periods, with the lowest value after room temperature storage ($p<0.05$).

DISCUSSION

During complete denture manufacturing, several factors are associated with base distortion[6, 9, 10, 12, 16] and artificial tooth displacement[18-22]. The occurrence of artificial tooth displacement observed on complete dentures remains a real and relevant factor, causing interference in the vertical dimension of occlusion and stability of dentures when in use.

For this reason, the aim of this study was to verify whether room temperature and water storage could promote changes in the distances between teeth, when compared to the denture deflasking period. The hypothesis tested that different types of storage could adversely affect the teeth position in the denture base was partially confirmed.

In general, the changes in the acrylic resins were not similar in relation to the stability of the I-I, PM-PM and M-M transverse distances, when the storage periods were compared ($p<0.05$). With regard to the I-I distance (Table 1), room temperature and water storage did not alter the original distance for the Classico and QC-20 resins ($p>0.05$), as observed for the Onda Cryl resin. The I-I distance for the Onda-Cryl resin was statistically higher at deflasking when compared to room temperature and water storage ($p<0.05$). This fact signifies that there was linear contraction in this distance at room temperature, and the water absorption occurred in the water storage was not sufficient to compensate the shrinkage showed at room temperature.

However, PM-PM and M-M distances showed some changes with both types of storage. Table 2 shows that the PM-PM distance was not statistically different for the Classico and Onda-Cryl resins at deflasking and both storage periods ($p>0.05$). Conversely, QC-20 resin showed a tendency to recuperate the original distance only after water storage. With the exception of Classico resin (Table 3), the M-M distance also showed a tendency to return to the original distance only after water storage.

Water sorption is reported to be dependent on the diffusion law, resulting in an increase in material volume. This phenomenon can partially compensate the acrylic resin shrinkage that occurs during the denture procedure[1]. According to a classic study, artificial teeth can change their position in the denture base, according to individual or combined factors[40].

Except for the Classico resin in the PM-PM distance (Table 2), there was no statistically significant difference in the I-I (Table 1) and M-M (Table 3) distances, when the resins were compared after deflasking ($p>0.05$). This fact signifies that a similar distortion occurred on the denture base during this period. It is possible that the resins show similar dimensional changes during the denture procedure and/or in the deflasking, whatever the polymerisation mode of each resin.

The combined action of several known and unknown factors may have been responsible for the lack of similarity in the change of the distances between teeth, mainly during room temperature storage. It is likely that the temperature and humidity level of the environment during the storage at room temperature was responsible for the drying of the denture base, resulting in contraction when compared to deflasking, mainly in the anteroposterior distances. After the room temperature and water storage periods, only Onda-Cryl presented lower values ($p<0.05$) for the I-I distance (Table 1).

It has been claimed that the most important factor affecting the contraction of the distance between molar teeth is the thickness of the resin, which controls the stiffness of the denture base, decreasing the distortion by a greater magnitude[41]. Probably, this type of discrepancy did not occur in the present study because the thicknesses of the denture bases were standardized at 2.0 mm[20], eliminating this factor among resins. In addition, the release of stresses induced in the acrylic resin base during the denture procedure[42] occurred during the deflasking. It is possible that this was responsible for the similarity of the changes in the majority of the distances between teeth in the present study.

Analyzing the tooth displacement that occurred during the flask closure and flask cooling methods, a more recent study showed no significant tooth displacement in the majority of the distances evaluated after denture deflasking. The tooth displacement was minimal and resulted from the release of residual stresses induced by the thermal contraction that occurs during the mould cooling[21].

There was no statistically significant difference among resins in the RI-RM (Table 4) and LI-LM (Table 5) distances at the deflasking, signifying that they were not influenced by the release of stresses. Despite the similarity between Classico and QC-20 resins at room temperature, Onda-Cryl resin showed a greater value for the RI-RM distance (Table 4) and a lower value for the LI-LM distance (Table 5) at this storage.

The influence of the dimensional changes of these resins on the distortion of the denture base and the effect of the water storage on the teeth displacement are complex events that are difficult to explain in the present work. However, divergent results have been reported by previous studies showing that the expansion occurs when the denture is immersed in water[1,37,38]. The water is absorbed at different amounts during resin polymerisation or during water storage[36,43], influencing the distortion level of the denture base. Probably, this fact causes different effects on the dimensional change of the denture base and consequent tooth displacement, which could affect the vertical dimension of occlusion. Tooth displacement during room temperature and water storage involves other factors that may occur during the complete denture procedure, such as base thickness[41], flask closure method[8], flask cooling method[19], and interproximal tooth contact[44].

Although it was not objective of this study to investigate the direction of the teeth displacement, it was possible to determine the changes that occur in the different distances between teeth. However, the changes promoted by the different storages were not sufficient to compensate or mitigate the distortion pattern that occurred in the denture deflasking. Future *in vivo* studies should be performed to better understand the effect of different storages on tooth displacement during oral use.

CLINICAL RELEVANCE

Dimensional changes that occur in the distances between teeth due to room temperature and water storage could cause interference in the vertical dimension of occlusion and stability of dentures when in use

CONCLUSIONS

Based on the results discussed, the following conclusions can be drawn: The distances between teeth were adversely affected by different storage methods. The water sorption was not sufficient to compensate the distortion that occurs during denture deflasking and at room temperature storage. Tooth displacement is still a complex factor that can influence the vertical dimension of occlusion and denture stability.

MANUFACTURERS' DETAILS

- Classico Dental Products, Sao Paulo, SP, Brazil: Batchs 906080 and 789325
- Dentsply, Petropolis, RJ, Brazil: Batchs 78772 and 9600/6995
- Vigodent, Rio de Janeiro, RJ, Brazil: Batch 3705
- Epoxiglass Chemical Industry, Diadema, SP, Brazil
- Bio-Art Dental Equipment, Sao Carlos, SP, Brazil
- Maillefer, Petropolis, RJ, Brazil
- Iara Industry and Trade, Sao Paulo, SP, Brazil
- Super Bonder; Henkel Loctite, Itapevi, SP, Brazil
- J. Safrany Metallurgy Co., Sao Paulo, SP, Brazil
- Olympus Optical Co., Tokyo, Japan
- Continental Domestic Lines, Manaus, AM, Brazil
- Delta Equipment, Sao Paulo, SP, Brazil

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