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# Dimensional stability of heat-activated acrylic resin at different time intervals by different flask cooling methods

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## Abstract

This study was design to investigate the dimensional stability of heat-activated acrylic resin with different methods of flask cooling (15 minutes rapid cooling, one hour bench cooling, four hours delayed deflasking, and 24 hours delayed deflasking) at different time intervals (immediately, two days, seven days, 30 days) after deflasking.

Heat-activated acrylic resin was used to prepare acrylic samples. Then, measurement of the distances where achieved between the centers of selected marks in the acrylic samples. They were measured at different time intervals for different methods of flask cooling.

The results showed that the group samples of the four hours and 24 hours of delayed deflasking was insignificantly different from the control and followed by the group of one hour bench cooling. The quenched group was significantly different from the control group.

The heat-activated acrylic resin should be kept in the flask for four hours or more after processing to achieve more accurate dentures.

**Key words: Dimensional stability, heat-activated acrylic resin, flask cooling, delayed deflasking.**

## Introduction

Acrylic resins are widely used for the construction of dentures and their overall performance is regarded as satisfactory.[1,2] Skinner & Cooper[3] suggested that there was a certain lack of dimensional stability which must be accepted as one of the disadvantages of acrylic resin dentures. At least two recognized dimensional changes were unavoidable in every acrylic resin denture; shrinkage and expansion. Heat-activated acrylic denture base resin is widely used for its many advantages and maintains its widespread use, despite the polymerization shrinkage.[3,4]

Dimensional stability is an essential and critical factor in the retention and stability of dentures, and later on the satisfaction of the patient. Many variables influence the dimensional changes occurring in a denture and these factors need to be considered during both the processing

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phase and the patient use.[2]

Wong, Cheng, Chow & Clark[5] suggested that there were minor differences in shrinkage of dentures by dry and wet heat processing with different rates of cooling, the final dimensions did not reveal any significant differences at water saturation. This finding implied that there was no superior method of heat processing of dentures with regard to dimensional accuracy, and the choice may be based on each person's preference and cost.

Komiyama & Kawara[6] in their study suggested that keeping a denture base fabricated with heat activated denture resin in its stone mold for at least one day or more after processing reduced the deformation associated with processing.

Kobayashi, Komiyama, Kimoto & Kawara[7] found that the residual internal stress in heat-activated acrylic resin in the region of shrinkage restriction was relaxed in the stone mold during the time of cooling and that dimensional changes after removing from the stone mold were reduced. Furthermore, Kimoto, Kobayashi, Kobayashi& Kawara[8] stated that the flask should be slowly cooled to room temperature, since the internal stresses developed by the thermal shrinkage would be relaxed during the cooling process.

The greater the surface contact that exists between the denture base and the cast, the better the adaptation will be to the oral tissue. This close adaptation of the denture surface to the oral mucosa will result in a more retentive denture.[9] It is, therefore, important to understand the best method of flask cooling that improves the dimensional stability of the acrylic denture base resin.

The aim of this study was to examine the dimensional stability of heat–activated acrylic resin by different methods of flask cooling; quenching (rapid cooling), one hour, four hours delayed deflasking, and 24 hours delayed deflasking after processing. Then, measure the dimensional stability of the acrylic resin samples placed in water at different time intervals; immediately, two days, seven days, and 30 days after deflasking.

## Materials & Method

Twelve heat-activated acrylic resin samples were incorporated in this research. They were constructed from a rectangular metal pattern with dimensions of (20) mm × (12) mm × (3) mm. The metal pattern contained four grooves, 2 mm away from its borders, in order to mark four (+) signs one at each corner.

Heat-activated acrylic denture base resin (Major base 2/ Italy) was mixed and packed according to manufacturer's instructions. After resin packing, the flasks were placed in a thermostatically controlled water bath (EWL 5501 Kavo WEL). The curing cycle was set for 90 minutes and started at 70 ˚C. After 60 minutes the temperature was raised to 100 ˚C and was sustained for 30 minutes.

The twelve samples that were prepared for this study were divided into four test groups. Each test group contained three samples. The test groups were divided according to the cooling method into:

- Quenched group: consisted of the samples that were obtained from the flasks that were rapidly cooled under running water for 15 minutes.
- Bench cooling for one hour: consisted of the samples that were obtained from the flasks that were left on the bench to cool for one hour.
- Delayed deflasking for four hours: consisted of the samples that were obtained from the flasks that were left on the bench to cool for four hours.

- Delayed deflasking for 24 hours: consisted of the samples that were obtained from the flasks that were left on the bench to cool for 24 hours.

The control group represented the dimensions before processing the acrylic.

The (+) signs that appeared in the acrylic samples were filled with blue casting wax to define the marks for measurement purposes (figure 1). Computerized scanning for the metal pattern was done, and for each acrylic sample in every group.

The distances between the centers of the selected marks were measured in (mm) using the computer program Corel Draw 11. The distances between the points A, B, C, and D (figure 1) were measured for each sample; AB, BD, DC, and CA (where AB is the distance from A to B and so on). Then, the numeric vectors[10] of these values were obtained from this formula:

$$\|\vec{V}\| = \sqrt{AB^2 + BD^2 + DC^2 + CA^2}$$

The measurements were made for the samples of each test group and at different time intervals. During this period of time the samples were kept in water. They were only brought out of water for measurement purposes and placed back again. The time intervals were; immediately after deflasking, two days after deflasking, seven days after deflasking, and 30 days after deflasking at which the acrylic achieves the maximum water saturation.[11]

The data was statistically analyzed with the computer program Statistical Package for Social Sciences (SPSS) version 15.0 for Windows. The means and standard deviations were obtained. Also, the Paired-Samples T-test was used to compare between the control and the test groups at different time intervals.

## Results

The means and standard deviations for the control group and the test groups are displayed in table (1).

The group samples that were constructed according to the quenching technique showed a significant difference (P<.05) for all the measurements; immediately, after two days, after seven days, and after 30 days of deflasking (table 2).

There was a significant difference (P<.05) for the measurements immediately and after two days for the samples of the one hour bench cooling, while the statistical analysis was insignificant (P>.05) for the measurements after seven and 30 days (table 3).

The samples of the four hours and 24 hours of delayed deflasking showed no significant difference (P>.05), when compared with the control group, at all four measurements; immediately, two days, seven days, and 30 days after deflasking (tables 4 & 5).

## Discussion

The dimensions of the samples were measured throughout the 30 days of immersion in water. This was to demonstrate the effect of water absorption on the dimensions of the acrylic samples and to measure the final dimensions of the samples after water saturation, since this was the final dimensions that the acrylic resin would demonstrate after full saturation.[1,11]

In this study it was found that the four hours and 24 hours of delayed deflasking produced the best dimensionally stable acrylic samples at all different time intervals of measurement. Leaving the samples in the flask for four hours or more seemed to have lessened the residual internal stresses generated from polymerization shrinkage and thermal shrinkage during processing of the acrylic. Thus, the resultant samples underwent less strain after deflasking and were more dimensionally stable. McCabe and Wilson[12] stated that the stress produced by thermal contraction is relieved shortly after the denture has been removed from the mold and that the stress, caused by polymerization contraction, will be relieved more gradually. The explanation of this observation is that the thermal contraction stresses are of an instantaneous mechanical nature, whereas the stresses caused by polymerization are on a molecular level, involving polymer chains.

Komiyama & Kawara[6] agreed with these findings as they suggested that keeping the denture base, fabricated with heat activated denture resin, in its stone mold after processing was effective for reducing deformation of the denture base. They disagreed in that they suggested leaving the denture bases in the molds for at least one day or more. Their difference maybe that they considered the controls as the samples removed from the flask four hours after the start of the bench cooling, while in this research the samples were compare with the measurements before processing the acrylic

Kobayashi et. al.[7] also found similar results but disagreed in the length of time the acrylic spent in the flask. They said that the residual internal stress in heat-activated acrylic resin in the region of shrinkage restriction was relaxed in the stone mold during the time of cooling and that dimensional changes after removing from the stone mold were reduced. They also suggested that gradual cooling for 12 hours or more after processing a heat-activated acrylic denture was effective in lessening deformation of the prosthesis. The difference in the period of time the acrylic spent in the flask, between this research and the one conducted by the authors above, perhaps can be attributable to two points. They compared the samples with the four hour bench cooling as controls, while in this research the samples were compare with the measurements before processing the acrylic resin. Also, their method of cooling was by leaving the flasks in an amount of water that cooled to room temperature for the required period of time, while in this research the flasks reached the room temperature in a shorter duration but were left in the flasks for the required period of time.

The group samples of the one hour bench cooling differed from the two groups of four hours and 24 hours of delayed deflasking. Immediately after deflasking and after two days there was a significant difference with the control group. This was due to the polymerization shrinkage and thermal shrinkage during processing of the acrylic. This difference diminished after seven days of water immersion which was the result of the swelling (expansion) of the resin due to the water absorption forcing the macromolecules apart.[1] The resultant increase in dimensions eliminated any statistical difference with the control.

The quenched group was significantly different from the control group at all measurement intervals; immediately, two days, seven days, and at 30 days. This was the result of the release of the internal stresses generated from the polymerization shrinkage and thermal shrinkage during processing of the acrylic. The absorption of water had no significant effect on the dimensions of the acrylic resin samples when compared with the controls.

Chen, Lacefield, and Castleberry[13] in their study stated that the rate of cooling of the flask had a definite effect upon the observed shrinkage of the dentures. During the sudden change in the temperature of the denture, caused by quenching in water, unequal thermal contraction in various areas occurs, and the resultant stress may have been partly relieved during deflasking, [6] thus inducing a greater amount of warpage. Also, they said that the difference in thermal contraction between the gypsum mold and the acrylic resin was believed to be the cause of residual strain in processed denture, and was also considered to be the main contributor to the strain release which occurred when the denture was separated from the cast. Thus, a significant difference in shrinkage between those dentures bench cooled and those quenched in water.

Kimoto et. al.[8] were in agreement and stated that the flask should be slowly cooled to room temperature, since the internal stresses developed by the thermal shrinkage would be relaxed during the cooling process. Ganzarolli, Rached, Garcia, & Del Bel Cury[14] also found similar results.

In conclusion, the heat-activated acrylic resin should be kept in the flask for four hours or more after processing to achieve more accurate dentures. The one hour bench cooling technique was also adequate in achieving satisfactory dentures after a period of seven days or more of immersion in water. The quenching in water was not an acceptable method for cooling heat-cured acrylic resin if the highest accuracy is to be obtained.

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**Figure (1):** Scanned picture for the acrylic resin sample

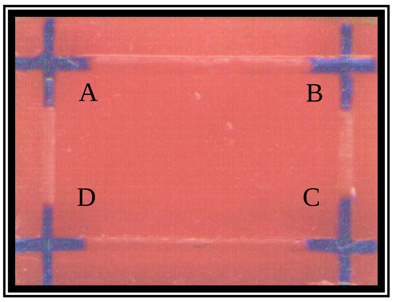


Table (1) Means and standard deviations for the control and test groups.

| Group | Time of measurement | Mean | Std. Deviation |
|---|---|---|---|
| control | | 33.0700 | .06083 |
| Quenching technique | Immediately | 32.8433 | .03786 |
| | 2 days | 32.8633 | .06351 |
| | 7 days | 32.9167 | .09018 |
| | 30 days | 32.9367 | .01528 |
| One hours bench cooling | Immediately | 32.9033 | .06028 |
| | 2 days | 32.9167 | .06506 |
| | 7 days | 32.9667 | .05859 |
| | 30 days | 32.9767 | .01528 |
| Four hours of delayed deflasking | Immediately | 32.8900 | .21656 |
| | 2 days | 32.9567 | .20984 |
| | 7 days | 32.9433 | .15011 |
| | 30 days | 32.9133 | .22898 |
| 24 hours of delayed deflasking | Immediately | 32.8833 | .04509 |
| | 2 days | 32.9333 | .11846 |
| | 7 days | 32.8733 | .05132 |
| | 30 days | 32.9300 | .08718 |

P>.05 (insignificant), P<.05 (significant), and P<.01 (highly significant)

Table (2) Paired-Samples T-Test between the quenched group and the control group at the different time intervals of measurement.

| Time interval | Mean diff. | Std. Deviation | t | P value |
|---|---|---|---|---|
| immediately | .22667 | .04509 | 8.707 | .013 |
| two days | .20667 | .05774 | 6.200 | .025 |
| seven days | .15333 | .04041 | 6.571 | .022 |
| 30 days | .13333 | .04933 | 4.682 | .043 |

P>.05 (insignificant), P<.05 (significant), and P<.01 (highly significant)

Table (3) Paired-Sample T-Test between the group of one hour bench cooling and the control group at the different time intervals of measurement.

| Time interval | Mean diff. | Std. Deviation | t | P value |
|---|---|---|---|---|
| Immediately | .16667 | .03215 | 8.980 | .012 |
| two days | .15333 | .03055 | 8.693 | .013 |
| seven days | .10333 | .04619 | 3.875 | .061 |
| 30 days | .09333 | .04933 | 3.277 | .082 |

P>.05 (insignificant), P<.05 (significant), and P<.01 (highly significant)

Table (4) Paired Samples Test between the group of four hours of delayed deflasking and the control group at the different time intervals of measurement.

| Time interval | Mean diff. | Std. Deviation | t | P value |
|---|---|---|---|---|
| immediately | .18000 | .15588 | 2.000 | .184 |
| two days | .11333 | .17039 | 1.152 | .368 |
| seven days | .12667 | .10017 | 2.190 | .160 |
| 30 days | .15667 | .16921 | 1.604 | .250 |

P>.05 (insignificant), P<.05 (significant), and P<.01 (highly significant)

Table (5) Paired Samples Test between the group of 24 hours of delayed deflasking and the control group at the different time intervals of measurement.

| Time interval | Mean diff. | Std. Deviation | t | P value |
|---|---|---|---|---|
| immediately | .18667 | .10017 | 3.228 | 084 |
| two days | .13667 | .05859 | 4.040 | .056 |
| seven days | .19667 | .08505 | 4.005 | .057 |
| 30 days | .14000 | .06557 | 3.698 | .066 |

P>.05 (insignificant), P<.05 (significant), and P<.01 (highly significant)