# Teeth Displacement and Palatal Adaptation of Autoclave Cured acrylic resin with Various Palates and Investments.

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## ABSTRACT

Background: The denture base inaccuracies during processing negatively influence the retention and stability of finished complete denture. The aims of this study were to evaluate teeth movement and palatal adaptation of autoclave cured denture bases and their relationship with palatal depths and investments.

Materials and methods: A nightly maxillary complete dentures prepared, processed and organized to be tested as follows: 1. Processing methods: water bath and autoclave with both fast and slow cycles. 2. Palatal depth: shallow, medium and deep. 3. Investing medium: stone and silicone. For every finished denture, two measurements were done: first: teeth movement by attaching metallic reference screws on the right and left centrals, first premolars and second molars. Second: palatal adaptation by sectioning the posterior part of the denture and measuring the distances between five selected points which were on the right and left: ridge crest, center of the vestibule and middle of the palate. Then two measurements were done before and after curing by using travelling microscope of 0.001% of accuracy. The collected data organized statistically by three ways analysis of variance for curing methods, investments and palatal depth. Also, least significant test and t test for detection of difference.

Results: High significant improvements in dimensional stability shows when autoclave was used compared with the water bath. Results show that autoclave curing reduces the amount of teeth movements and improves palatal adaptation with silicone investment compared with stone.

Conclusions: resin curing by autoclave is a better alternative to water bath. The dimensional stability were improved especially when silicone were used instead of stone.

Key words: Teeth movements, palatal adaptation, silicone investment, travelling microscope. (J Bagh Coll Dentistry 2016; 28(1):1-10).

## INTRODUCTION

The polymers subjected to curing expansion during heating and both types of thermal shrinkages (curing and cooling), so higher molecular weight polymers will be polymerized immediately leading to those areas of less polymerization move toward areas of higher one and creating stress which in turn leads to dimensional changes in the cured dentures. [(1,2)]

Palatal configuration of maxillary arch and particularly the deep one plays vital role in the dimensional stability of the upper complete dentures especially the adaptation to the underlying mucosa, so poor palatal seal leads to instability and poor retention of the dental prosthesis. [(3)] Especially in the posterior part where least resistant points because it lies in thin and weak sections leading to more stress relaxation and more inaccuracies. [(4)]

When acrylic were cured, the dimensional changes after curing in addition with a multiple distortions when flasks is allowed to cool and then opened resulted in inaccuracies leading to horizontal and even vertical teeth displacements and errors, ends with changes in occlusal patterns. [(5)]

The silicone increasingly regarded as a successful alternative to hard stone as investment especially when accuracy is regarded. [(6)]

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The benefits were; easily and cleanly flasking, free from any opportunity of denture warp page after de-flasking. However, the relationship between investment materials and teeth displacement and palatal adaptation need further investigations. [(7)]

Heat curing of acrylic resin considered the best method, and provides a lot of advantages including simple technique with cheap devices. Although it had many disadvantages especially long curing time. [(8)] The better curing is the fast one, and the studies indicated that the fast method is suitable for denture bases with multiple sizes, shapes and palatal configurations. [(9)]

Autoclave curing depends on elevating water temperature more than 100°C in an evacuated chamber, so raising the pressure inside it. [(10)] Its fast and slow cycles achieves better results in the mechanical properties when compared with the water bath. [(11)]

The measurements of teeth movements and palatal adaptation were done by the use of travelling microscope to record minor inaccuracies. [(4)]

The purpose of the present research was to determine teeth movement and palatal adaptation of acrylic resins with multiple palatal depths (***shallow, medium and deep***) cured by (water bath and ***fast and slow*** autoclave ***cycles***) with two investments (stone and silicone).

## MATERIALS AND METHODS

A metal maxillary edentulous brass cast (***standardized, New York, USA***) were selected to make a silicon master mold (***Columbia dent form Corp.***). A three palatal depths (***shallow, medium and deep***) were obtained by addition of wax layers (***Shanghai New Century Dental material, China***) to the palate of silicone mold and so the mold without addition represent the shallow. While the medium depth had a palatal depth of (***13mm***). On the other hand, the deep palatal depth were ***18mm***. [12] After that, type IV stone (***Elite model, Zhermack technical, Italy***) of 100gm/30ml poured inside these molds by using vibrator (***Quayle Dental, England***) and remained setting for 45min before getting the casts.

The depth of the palate were estimated by cast fixation to the surveyor (***Milling machine, AF30, Switzerland***) with a zero tilting, then half circular ruler (***China plastic industry***) placed on the ridge. After that, digital vernia (***Shanghai Shenhanme asuringtools Co., LTD, China***) touches the ruler and refer to palatal center at the point of union between incisive papilla and fovea palatine uniting line. [12]

Then, 90 stone casts were duplicated by using plastic flask (***Clear Cast flask, vertex, Netherlands***) by attaching them to the lower half with melted wax, then the upper half connected to the base. Later, the agar (***Castagel, Vertex-Dental, Netherlands***) were liquefied in a water bath (***EWL 55 01, West Germany***) at (***92ºC***) followed by tempering at (***48ºC***) to fill the flask completely and allowed to solidify for one hour. [13] After that, the cast was removed and the created mold was poured with type IV stone. These steps were repeated until the intended number of casts were made. As illustrated in figure 1.

**Figure 1: the parts of the plastic duplication flask which were used for cast duplication.**

Biostar device (***SCHU-DENTAL, Germany***) were used for construction of clear thermoplastic cakes (***Biocryl C, SCHEU-Dental, Iserlohn, Germany***) in order to make 2mm thickness record bases for all the casts and palatal depths depending on manufacturer recommendations. [14]

When the intended record bases completed, occlusal rims were made by attaching bite rim wax with standard measurement of 22 mm and 18mm for length anteriorly and posteriorly and 4mm and 7mm for width respectively. [15]

Conventional mounting procedure were used to attach the maxillary cast to the upper member of a semi adjustable articulator (***Model H2, HANAU Eng. Co. Buffalo, New York, and USA***). The articulator parameters were: the tip of Bonwill triangle were equilibrated with the central area of the record base at the incisal area, to orient the cast accurately in the anterior-posterior plane. Then the incisal pins were oriented according to the record base midline and fixed at zero degree. Finally, the condylar track and Bennett angles were sets at 30 and 10 degrees respectively. The mounting completed with the aid of a metal plate (***China, Brass***) attached to the lower member of the articulator by metal screw and fixed in the mid distance between the two members, the articulator were closed in order to proximate the incisal pins to zero degree. [16]

After that, an arbitrary face bow (***Dentatus, Sweden***) used to make orientation of occlusal plane by selection of two points posteriorly in the condylar area and one point anteriorly at the incisal pin. [16] Then the arrangement of acrylic teeth (***Florident, cross linked, shade No.3, china***) were done with the aid of a universal dentate silicone mold (***Columbia dent form Corp., New York, USA***). The teeth were placed in the teeth imprint of the mold and then melted wax was poured inside it to simulate the gingival contour of the waxed denture, the teeth with wax were carefully removed from the mold after wax solidification and then luted to the maxillary bite rims with the aid of hot spatula. [16] As illustrated in figure (2).

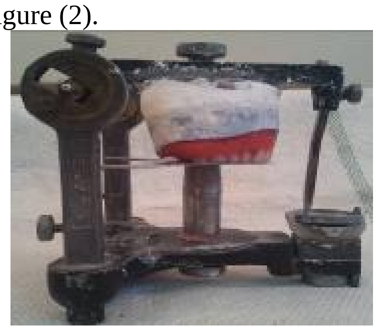

**Figure 2: articulator with cast and arranged teeth fixed to the upper member while the metal plate attached to the lower one**.

For teeth movements, selected points were chosen on the teeth which were:

1. The center of the incisal edge of the right and left central incisors (RI&LI).

2. The buccal cusps of the right and left first premolars (RP&LP).

3. The mesio buccal cusps of the right and left second molars (RM&LM).

Then, metallic reference screws (***Dentsply-Maillefer, Swiss***) with 3mm length and 2mm diameter attached to these points after drilling a hole of 3mm depth with round carbide bur and plastic stopper to standardize drilling.

Fixation were by cyanoacrylate adhesive (***Cyanoacrylate adhesive material, Japan***) and the distances between these points were standardized for all samples before acrylic resin curing and measured by travelling microscope as follows:

**A**. Mediolatral points include:

**1**. M-M (right to left molar)**.**

**2**. P-P (right to left premolar).

**B**.Anteriposterior points which include:

**3**. RM-RP (right molar to right premolar).

**4**. RP-RI (right premolar to right incisor).

**5**. RM-RI (right molar to right incisor)**.**

**6**. LM-LP (left molar to left premolar).

**7**. LP-LI (left premolar to left incisor).

**8**. LM-LI (left molar to left incisor). [16]

As shown in figure (3, A).

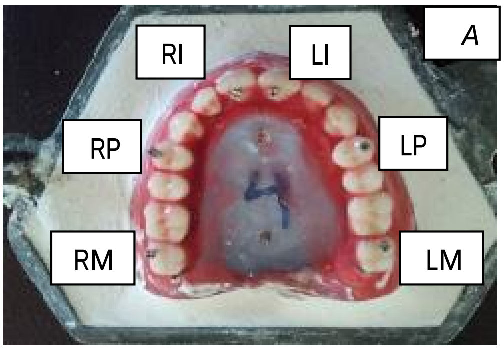


**Figure 3, A: the reference points for teeth movements.**

On the other hand, palatal adaptation of the internal surface of the acrylic resin and the external surface of the stone cast were estimated as follows:

The length of the cast were measured as 52mm and the line of cutting were positioned at 39mm from the anterior border of the cast leaving 13mm to be cuts by using saw machine operated manually at a range of two transverse cuts for each seconds with continues water supply for cooling and the cast were separated in the area behind the second molar in front of the posterior palatal seal area and the selected points were measured by using the same travelling microscope in order to measure the space of separation at five previously selected areas which represents the right and left vestibules (RV&LV), the right and left crest of residual ridge (RC&LC) and finally the mid palatal area (M).[17] as illustrated in figure (4,B).

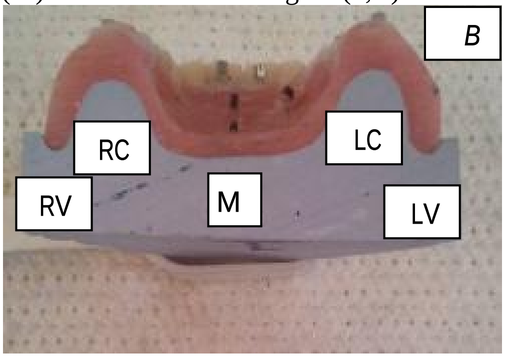


**Figure 4, B: the reference point for posterior palatal adaptation.**

The distances before and after resin curing were measured and compared. The casts were arranged depending on the curing methods, in two major groups: the first one include 30 cast and cured with water bath, the second one include 60 cast cured with autoclave and include ***(30 cast for fast cycle and 30 for the slow one)***. Each group contains 3 palatal depths; (***shallow, medium and deep***) with 10 casts for each, 5 casts invested with stone and 5 invested with silicone.

Casts were placed inside flask lower half (***BRODEN, Sweden***) by pouring type II plaster ***(AL-AHLYA, Iraq).*** after a setting of 45 min, a separating medium (***Swindon, England***) painted and allowed for 5 min setting, then type IV stone were poured in the upper half of the flask around the waxed denture and allowed to set for 60 minutes. [16] Same steps were followed when using silicone investment so the base and catalyst of silicon (***Castasil 21, Vertex-Dental, Netherlands***) in amount of 200ml were uniformly mixed in plastic bowl according to manufacturer instructions, and silicone were placed in the upper half of the flask, and allowed to set in 20 minutes. [18]

During wax elimination, the flasks were placed inside 100C° water for about 5 minutes. After that the casts and teeth were flushed with 100C°water and soup and then allowed to dry before the separating medium were applied to the two portions of the flask except the teeth ridge lap. [16]

Resin base (***Regular, TM, Vertex-Dental, Netherlands***) with P/L of 1:3 were mixed in mixing jar by stiff spatula for a half minutes and covered with glass slap for 15 minutes to reach dough stage. Then it packed with a pressure of 20 bars. acrylic access were removed with wax knife and then placed under a hydraulic press (***BREMER GOLDSCHLAGEREI WILH,***

***HERBST West Germany***) with 1250 kgf for 5 minutes and then clamed (***Ash Co., England***) and cured in water bath (***Digital water bath, labTech***) for 1.5 hours at 73C° and then 30 minutes at 100ºC. [16] The autoclave curing were done with digital autoclave (***EURONDA, type B inspection***) by two curing cycles, fast and slow one. So the clamped flasks were seated inside the evacuation vessel and the door closed securely. Curing done by choosing cycles stored in the machine memory. [19] And as illustrated in table (1).

**Table 1: showing the curing cycles for the autoclave.**

| No. | Curing Cycle | Temperature | Pressure Applied | Time |
|---|---|---|---|---|
| **1** | Fast | 121°C | 210 Kpa | 15 Minutes |
| **2** | Slow | 121°C | 210 Kpa | 30 Minutes |

Digital control panel were used to monitor the progress of curing including: exchange of air with steam, elevation of temperature and maintaining it for sterilization and then reducing it at the end of the cycle, with again exchanging the steam with air. When the curing finished, the flasks were allowed for bench cooling at 23ºC, then the samples were deflasked and finished and polished according to the manufacturer recommendation. ADA specification No.12 for samples storage were followed, so for teeth movements measurements were done immediately after deflasking,[16] for palatal adaptation, casts with their denture base were measured after storage in 20°C and 50% humidity in an incubator ***(Bamb, Galen, England)***.[20]

Statistical analysis of the distances before and after curing estimate the amount of dimensional changes as being positive or negative for expansion or contraction simultaneously. The data were according to tests applied; F-test applied for investing medium and curing methods with their relation with palatal depth. Also T-test and LSD for relation between groups and subgroups at significance value of 0.05%.

## RESULTS

The means in (mm) and standard deviations for teeth movements and palatal adaptation were presented in figures 5,6,7,8,9,10.

The three way ANOVA (F test) for palatal depth interference with investment materials and curing methods shows a high significant differences (P-value<0.01) for both teeth movements and palatal adaptation and these were showed in table 2.

Also the least significant test LSD for the comparison between each curing methods and palatal depth showed the following findings:

**Water bath:** silicone investment showed better dimensional accuracy than stone in teeth movement, while the stone were better than silicone in palatal adaptation.

**Fast autoclave cycle:** silicone showed better dimensional magnitude than stone in both teeth movement and palatal adaptation.

**Slow autoclave cycle:** stone were better than silicone in teeth movements. While for the palatal adaptation, the stone showed higher dimensional changes especially in medium palate when compared with the shallow one. While silicone showed better improvement when deep palate compared with the shallow one. As showed in table 3 and 4.

**Curing methods:**

T-test for the differences between the control (water bath and stone investment) and (fast autoclave with both stone and silicone) revealed a high significant reduction (P-value<0.01) in teeth movements and palatal adaptation.

While for the slow curing when compared with the control one, results revealed that the best reduction in dimensional changes was in silicone especially in palatal adaptation.

On the other hand, when fast and slow curing were compared, results indicate significant decrease in the teeth movement when slow cycle and stone investment were used. Also, the slow one proves better palatal adaptation, but when silicone investment was used. And these findings were shown in table 5.

**Type of investment:**

T-test indicated that silicone investment have better dimensional stability than stone for all curing methods and all palatal depths. this was illustrated in table 6.

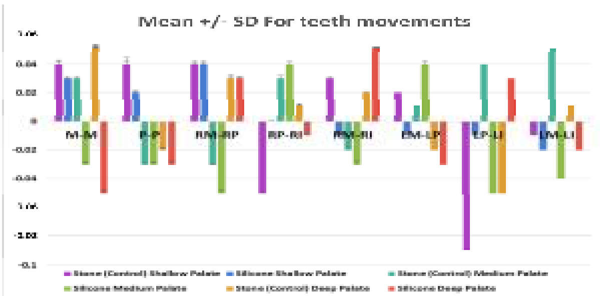


**Fig. 5: Bar Chart Shows the mean and standard deviations for both teeth movements when acrylic resin processed by water bath.**

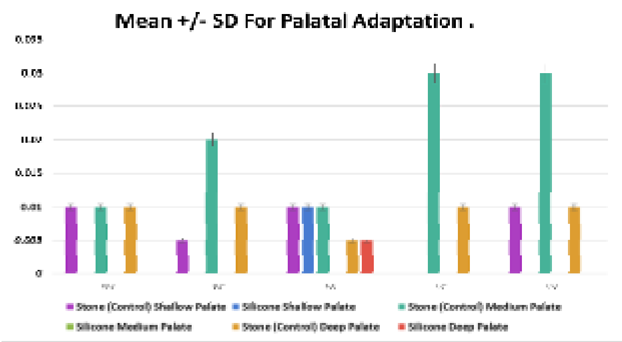


**Fig. 6: Bar Chart Shows the mean and standard deviations for both Palatal Adaptation when acrylic resin processed by water bath.**

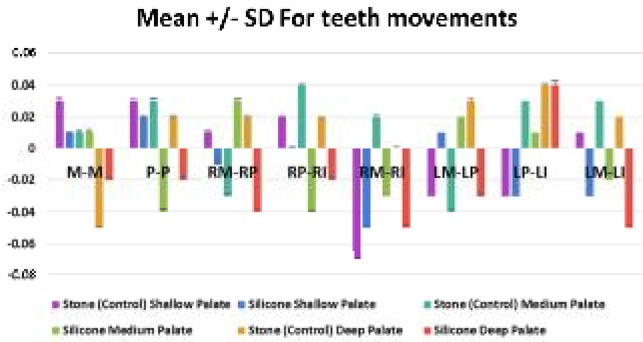


**Fig. 7: Bar Chart Shows the mean and standard deviations for both teeth movements when acrylic resin processed by fast autoclave cycle.**

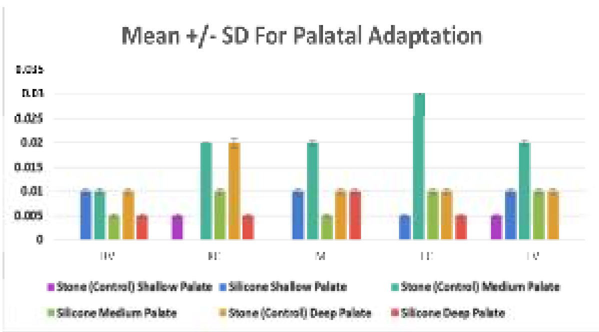


**Fig. 8: Bar Chart Shows the mean and standard deviations for both Palatal Adaptation when acrylic resin processed by fast autoclave cycle.**

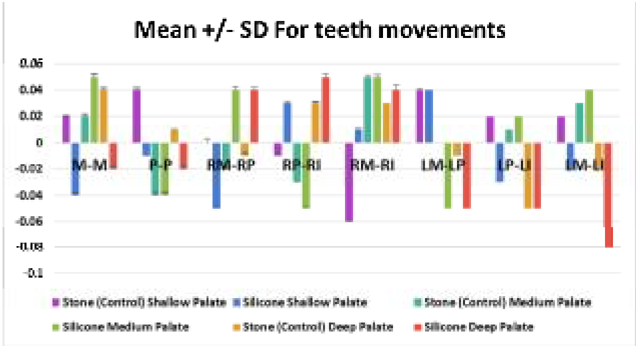


**Fig. 9: Bar Chart Shows the mean and standard deviations for both teeth movements when acrylic resin processed by Slow autoclave cycle**

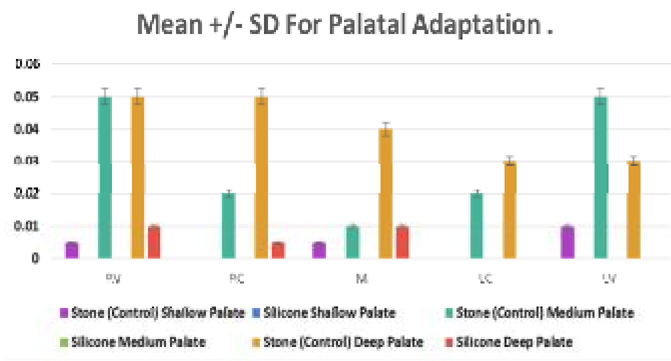


**Fig. 10: Bar Chart Shows the mean and standard deviations for both Palatal Adaptation when acrylic resin processed by Slow autoclave cycle.**

**Table 2: the F test for comparison between curing methods and investments with palatal depths for both teeth movements and palatal adaptation.**

| Teeth movements Points | | F test shallow & medium &deep palate | | | |
|---|---|---|---|---|---|
| | | Stone | | Silicone | |
| | | F test | Sig | F test | sig |
| Water bath | M-M | 30.36 | HS | 50.03 | HS |
| | P-P | 12.32 | HS | 20.23 | HS |
| | RM-RP | 50.03 | HS | 30.03 | HS |
| | RP-RI | 15.03 | HS | 61.06 | HS |
| | RM-RI | 10.03 | HS | 15.023 | HS |
| | LM-LP | 89.23 | HS | 33.03 | HS |
| | LP-LI | 50.02 | HS | 15.023 | HS |
| | LM-LI | 19.03 | HS | 13.03 | HS |
| Fast cycle | M-M | 61.03 | HS | 13.33 | HS |
| | P-P | 20.033 | HS | 13.03 | HS |
| | RM-RP | 48.3 | HS | 33.3 | HS |
| | RP-RI | 13.03 | HS | 48.3 | HS |
| | RM-RI | 42.06 | HS | 25.31 | HS |
| | LM-LP | 12.03 | HS | 48.03 | HS |
| | LP-LI | 50.02 | HS | 33.33 | HS |
| | LM-LI | 48.3 | HS | 82.2 | HS |
| Slow cycle | M-M | 8.93 | HS | 66.03 | HS |
| | P-P | 22.43 | HS | 27.32 | HS |
| | RM-RP | 48.0 | HS | 10.04 | HS |
| | RP-RI | 32.34 | HS | 25.32 | HS |
| | RM-RI | 87.32 | HS | 13.03 | HS |
| | LM-LP | 61.03 | HS | 83.3 | HS |
| | LP-LI | 15.03 | HS | 82.35 | HS |
| | LM-LI | 10.32 | HS | 36.36 | HS |
| Palatal adaptation Points | | F test shallow & medium &deep palate | | | |
| | | Stone | | Silicone | |
| | | F test | sig | F test | sig |
| Water bath | RV | 0.00 | NS | 0.00 | NS |
| | RC | 11.667 | Hsg | 0.00 | NS |
| | M | 1.667 | NS | 56.00 | NS |
| | LC | 12.11 | HS | 0.00 | NS |
| | LV | 16.034 | HS | 0.00 | NS |
| Fast cycle | RV | 4.033 | HS | 21.33 | HS |
| | RC | 16.26 | HS | 56.00 | HS |
| | M | 4.833 | HS | 42.667 | HS |
| | LC | 12.11 | HS | 21.333 | HS |
| | LV | 16.26 | HS | 40.03 | HS |
| Slow cycle | RV | 15.36 | HS | 8.033 | HS |
| | RC | 8.033 | HS | 2.667 | NS |
| | M | 80.26 | HS | 8.033 | HS |
| | LC | 14.034 | HS | 0.00 | NS |
| | LV | 41.6 | HS | 0.00 | NS |

**Table 3: LSD test for the comparison between the curing methods and stone investment for palatal depths in teeth movements and palatal adaptation.**

| Teeth movements Points | | LSD (Teeth movement) stone investment | | | | | |
|---|---|---|---|---|---|---|---|
| | | Shallow&Medium | | Shallow&Deep | | Medium&Deep | |
| | | Sig | Ch | Sig | Ch | Sig | Ch |
| Water bath | M-M | HS | ¤ | HS | ¤ | HS | ¤ |
| | P-P | HS | ¤ | HS | ¤ | HS | ¤ |
| | RM-RP | HS | ¤ | NS | ¤ | HS | ¤ |
| | RP-RI | HS | £ | HS | £ | HS | ¤ |
| | RM-RI | HS | ¤ | HS | ¤ | NS | £ |
| | LM-LP | HS | ¤ | NS | ¤ | HS | ¤ |
| | LP-LI | HS | £ | HS | £ | HS | ¤ |
| | LM-LI | HS | ¤ | NS | ¤ | HS | ¤ |
| Fast cycle | M-M | HS | ¤ | HS | ¤ | HS | ¤ |
| | P-P | NS | ¤ | HS | ¤ | HS | ¤ |
| | RM-RP | HS | ¤ | HS | £ | HS | £ |
| | RP-RI | HS | ¤ | NS | = | HS | ¤ |
| | RM-RI | HS | ¤ | HS | £ | HS | £ |
| | LM-LP | HS | ¤ | HS | £ | HS | £ |
| | LP-LI | NS | £ | HS | £ | HS | £ |
| | LM-LI | HS | £ | HS | £ | HS | £ |
| Slow cycle | M-M | NS | = | HS | £ | HS | £ |
| | P-P | NS | £ | HS | ¤ | HS | £ |
| | RM-RP | HS | £ | HS | ¤ | HS | £ |
| | RP-RI | HS | £ | HS | £ | NS | £ |
| | RM-RI | HS | £ | HS | ¤ | HS | ¤ |
| | LM-LP | HS | ¤ | HS | ¤ | HS | ¤ |
| | LP-LI | HS | £ | HS | ¤ | HS | ¤ |
| | LM-LI | HS | £ | HS | ¤ | NS | ¤ |
| Palatal adaptation Points | | LSD (Palatal adaptation) | | | | | |
| | | Shallow&Medium | | Shallow&Deep | | Medium&Deep | |
| | | Sig | Ch | Sig | Ch | Sig | Ch |
| Water bath | RV | NS | = | NS | = | NS | = |
| | RC | HS | £ | NS | £ | S | ¤ |
| | M | NS | = | NS | ¤ | NS | ¤ |
| | LC | HS | £ | NS | £ | S | ¤ |
| | LV | HS | £ | NS | = | HS | ¤ |
| Fast cycle | RV | HS | £ | HS | £ | NS | = |
| | RC | HS | £ | HS | £ | NS | = |
| | M | HS | £ | HS | £ | HS | ¤ |
| | LC | HS | £ | NS | £ | S | ¤ |
| | LV | HS | £ | HS | £ | HS | ¤ |
| Slow cycle | RV | HS | £ | HS | £ | NS | £ |
| | RC | NS | £ | HS | £ | HS | £ |
| | M | HS | £ | HS | £ | HS | £ |
| | LC | HS | £ | HS | £ | HS | £ |
| | LV | HS | £ | HS | £ | HS | ¤ |

**Table 4: LSD test for the comparison between the curing methods and sillicone investment for palatal depths in teeth**

| Teeth movements Points | | LSD (Teeth movement) silicone investment | | | | | |
|---|---|---|---|---|---|---|---|
| | | Shallow& Medium | | Shallow& Deep | | Medium& Deep | |
| | | Sig | Ch | Sig | Ch | Sig | Ch |
| Water bath | M-M | NS | ¤ | NS | ¤ | HS | ¤ |
| | P-P | HS | ¤ | HS | ¤ | NS | ¤ |
| | RM-RP | HS | ¤ | HS | ¤ | HS | £ |
| | RP-RI | HS | £ | HS | ¤ | HS | ¤ |
| | RM-RI | HS | ¤ | HS | £ | HS | £ |
| | LM-LP | HS | £ | HS | ¤ | HS | ¤ |
| | LP-LI | HS | ¤ | HS | £ | HS | £ |
| | LM-LI | HS | ¤ | HS | ¤ | NS | £ |
| Fast cycle | M-M | NS | = | HS | ¤ | HS | ¤ |
| | P-P | HS | ¤ | NS | ¤ | HS | £ |
| | RM-RP | HS | £ | HS | ¤ | HS | ¤ |
| | RP-RI | HS | ¤ | HS | ¤ | HS | £ |
| | RM-RI | HS | £ | NS | ¤ | HS | ¤ |
| | LM-LP | HS | £ | HS | ¤ | HS | ¤ |
| | LP-LI | HS | £ | HS | £ | HS | £ |
| | LM-LI | HS | £ | HS | ¤ | HS | ¤ |
| Slow cycle | M-M | HS | £ | HS | £ | HS | ¤ |
| | P-P | HS | £ | HS | £ | HS | £ |
| | RM-RP | HS | £ | HS | £ | HS | £ |
| | RP-RI | HS | £ | HS | £ | NS | £ |
| | RM-RI | HS | £ | HS | £ | HS | ¤ |
| | LM-LP | HS | ¤ | NS | ¤ | HS | £ |
| | LP-LI | HS | £ | HS | ¤ | HS | ¤ |
| | LM-LI | HS | £ | HS | ¤ | HS | ¤ |
| Palatal adaptation Points | | LSD (Palatal adaptation) | | | | | |
| | | Shallow& Medium | | Shallow& Deep | | Medium& Deep | |
| | | Sig | Ch | Sig | Ch | Sig | Ch |
| Water bath | RV | NS | = | NS | = | NS | = |
| | RC | NS | = | NS | = | NS | = |
| | M | HS | ¤ | HS | ¤ | NS | £ |
| | LC | NS | = | NS | = | NS | = |
| | LV | NS | = | NS | = | NS | = |
| Fast cycle | RV | HS | ¤ | HS | ¤ | NS | = |
| | RC | HS | £ | NS | £ | HS | ¤ |
| | M | HS | ¤ | NS | = | HS | £ |
| | LC | HS | £ | NS | ¤ | NS | ¤ |
| | LV | NS | = | HS | ¤ | HS | ¤ |
| Slow cycle | RV | NS | = | HS | £ | HS | £ |
| | RC | NS | = | NS | £ | NS | £ |
| | M | NS | = | HS | £ | HS | £ |
| | LC | NS | = | NS | = | NS | = |
| | LV | NS | = | NS | = | NS | = |

**Table 5: T test for comparison between A:control and fast autoclave curing cycles, B: Control and slow autoclave curing cycles, C: Fast and Slow autoclave curing cycles for palatal depths and investment materials.**

A

**A**

| Teeth movement | Points | T test control & Fast cycle (Teeth movement) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Stone | | | Silicone | | |
| | | T test | Sig. | Ch. | T test | Sig. | Ch. |
| Shallow | M-M | 22.33 | S | ¤ | 33.26 | S | ¤ |
| | P-P | 23.65 | S | ¤ | 31.25 | S | ¤ |
| | RM-RP | 12.56 | S | ¤ | 12.58 | S | ¤ |
| | RP-RI | 14.25 | S | £ | 1.00 | NS | £ |
| | RM-RI | 18.98 | S | ¤ | 30.78 | S | ¤ |
| | LM-LP | 24.28 | S | ¤ | 14.56 | S | ¤ |
| | LP-LI | 20.87 | S | £ | 17.29 | S | £ |
| | LM-LI | 1.00 | NS | £ | 33.65 | S | ¤ |
| Medium | M-M | 13.87 | S | ¤ | 17.25 | S | ¤ |
| | P-P | 1.00 | NS | £ | 16.35 | S | ¤ |
| | RM-RP | 1.00 | NS | = | 1.00 | NS | £ |
| | RP-RI | 30.87 | S | £ | 30.35 | S | ¤ |
| | RM-RI | 26.28 | S | £ | 33.26 | S | ¤ |
| | LM-LP | 55.23 | S | ¤ | 12.35 | S | £ |
| | LP-LI | 14.12 | S | ¤ | 17.89 | S | ¤ |
| | LM-LI | 17.89 | S | ¤ | 34.26 | S | ¤ |
| Deep | M-M | 10.65 | S | ¤ | 27.36 | S | ¤ |
| | P-P | 1.00 | S | £ | 1.00 | NS | = |
| | RM-RP | 18.98 | S | ¤ | 17.089 | S | ¤ |
| | RP-RI | 15.36 | S | £ | 13.25 | S | ¤ |
| | RM-RI | 17.58 | S | ¤ | 23.27 | S | ¤ |
| | LM-LP | 22.30 | S | £ | 18.36 | S | ¤ |
| | LP-LI | 27.47 | S | £ | 62.38 | S | £ |
| | LM-LI | 30.56 | S | £ | 66.98 | S | ¤ |
| Palatal adaptation | Points | T test control & Fast cycle (palatal adaptation) | | | | | |
| | | Stone | | | Silicone | | |
| | | T test | Sig. | Ch. | T test | Sig. | Ch. |
| Shallow | RV | 0 | - | ¤ | 1.00 | NS | = |
| | RC | 1.00 | NS | = | 0 | - | ¤ |
| | M | 0 | - | ¤ | 1.00 | NS | = |
| | LC | 0 | - | = | 0 | - | £ |
| | LV | 31.25 | S | ¤ | 1.00 | NS | = |
| Medium | RV | 1.00 | NS | = | 23.28 | S | ¤ |
| | RC | 1.00 | NS | = | 24.02 | S | ¤ |
| | M | 13.25 | S | £ | 17.29 | S | ¤ |
| | LC | 1.00 | NS | = | 23.56 | S | ¤ |
| | LV | 51.08 | S | ¤ | 17.36 | S | ¤ |
| Deep | RV | 1.00 | NS | = | 18.98 | S | ¤ |
| | RC | 45.06 | S | £ | 58.36 | S | ¤ |
| | M | 30.25 | S | £ | 30.25 | S | £ |
| | LC | 1.00 | NS | = | 60.08 | S | ¤ |
| | LV | 1.00 | NS | = | 0 | - | ¤ |

B

| Teeth movement | Points | T test control & Slow cycle (Teeth movement) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Stone | | | Silicone | | |
| | | T test | Sig. | Ch. | T test | Sig. | Ch. |
| Shallow | M-M | 12.35 | S | ¤ | 1.00 | NS | ¤ |
| | P-P | 1.00 | NS | = | 30.35 | S | ¤ |
| | RM-RP | 74.25 | S | ¤ | 33.26 | S | ¤ |
| | RP-RI | 55.36 | S | £ | 12.35 | S | £ |
| | RM-RI | 25.36 | S | ¤ | 17.89 | S | ¤ |
| | LM-LP | 18.98 | S | £ | 34.26 | S | £ |
| | LP-LI | 92.47 | S | £ | 22.65 | S | £ |
| | LM-LI | 30.65 | S | £ | 17.98 | S | ¤ |
| Medium | M-M | 26.25 | S | ¤ | 26.25 | S | £ |
| | P-P | 24.29 | S | ¤ | 24.29 | S | ¤ |
| | RM-RP | 19.30 | S | £ | 19.30 | S | £ |
| | RP-RI | 1.00 | NS | ¤ | 26.25 | S | ¤ |
| | RM-RI | 44.23 | S | £ | 26.25 | S | £ |
| | LM-LP | 47.56 | S | ¤ | 24.29 | S | ¤ |
| | LP-LI | 24.32 | S | ¤ | 19.30 | S | ¤ |
| | LM-LI | 18.90 | S | ¤ | 26.25 | S | ¤ |
| Deep | M-M | 27.03 | S | ¤ | 27.36 | S | ¤ |
| | P-P | 15.09 | S | £ | 1.00 | NS | = |
| | RM-RP | 23.56 | S | ¤ | 30.78 | S | £ |
| | RP-RI | 24.18 | S | £ | 14.56 | S | £ |
| | RM-RI | 19.65 | S | £ | 17.29 | S | £ |
| | LM-LP | 30.78 | S | £ | 33.65 | S | ¤ |
| | LP-LI | 1.00 | NS | = | 1.00 | NS | = |
| | LM-LI | 16.23 | S | ¤ | 28.26 | S | ¤ |
| Palatal adaptation | Points | T test control & Slow cycle (palatal adaptation) | | | | | |
| | | Stone | | | Silicone | | |
| | | T test | Sig. | Ch. | T test | Sig. | Ch. |
| Shallow | RV | 17.56 | S | ¤ | 0 | - | ¤ |
| | RC | 0 | - | ¤ | 0 | - | ¤ |
| | M | 30.08 | S | ¤ | 0 | - | ¤ |
| | LC | 0 | - | = | 0 | - | = |
| | LV | 1.00 | NS | = | 0 | - | ¤ |
| Medium | RV | 56.03 | S | £ | 0 | - | ¤ |
| | RC | 1.00 | NS | = | 0 | - | ¤ |
| | M | 1.00 | NS | = | 0 | - | ¤ |
| | LC | 40.08 | S | ¤ | 0 | - | ¤ |
| | LV | 19.36 | S | £ | 0 | - | ¤ |
| Deep | RV | 71.25 | S | £ | 1.00 | NS | = |
| | RC | 89.36 | S | £ | 33.25 | S | ¤ |
| | M | 23.05 | S | £ | 17.26 | S | £ |
| | LC | 24.06 | S | £ | 0 | - | ¤ |
| | LV | 14.23 | S | £ | 0 | - | ¤ |

C

| Teeth movement | Points | T test Fast & Slow cycle (Teeth movement) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Stone | | | Silicone | | |
| | | T test | Sig. | Ch. | T test | Sig. | Ch. |
| Shallow | M-M | 17.02 | S | ¤ | 10.25 | S | ¤ |
| | P-P | 22.30 | S | £ | 10.00 | S | ¤ |
| | RM-RP | 1.00 | NS | ¤ | 11.08 | S | ¤ |
| | RP-RI | 23.06 | S | ¤ | 1.00 | NS | £ |
| | RM-RI | 17.01 | S | £ | 12.89 | S | £ |
| | LM-LP | 14.25 | S | £ | 18.9 | S | £ |
| | LP-LI | 30.6 | S | £ | 1.00 | NS | = |
| | LM-LI | 18.9 | S | £ | 21.25 | S | £ |
| Medium | M-M | 27.02 | S | £ | 10.54 | S | £ |
| | P-P | 22.8 | S | ¤ | 1.00 | NS | = |
| | RM-RP | 36.9 | S | £ | 14.52 | S | £ |
| | RP-RI | 27.02 | S | ¤ | 23.69 | S | ¤ |
| | RM-RI | 28.03 | S | £ | 17.89 | S | £ |
| | LM-LP | 1.00 | NS | £ | 12.35 | S | ¤ |
| | LP-LI | 12.39 | S | ¤ | 14.87 | S | £ |
| | LM-LI | 1.00 | NS | = | 23.22 | S | £ |
| Deep | M-M | 18.99 | S | £ | 1.00 | NS | = |
| | P-P | 18.02 | S | ¤ | 1.00 | NS | = |
| | RM-RP | 17.89 | S | ¤ | 23.65 | S | £ |
| | RP-RI | 23.65 | S | £ | 12.47 | S | £ |
| | RM-RI | 1.00 | NS | £ | 18.98 | S | £ |
| | LM-LP | 18.02 | S | ¤ | 25.32 | S | = |
| | LP-LI | 14.02 | S | ¤ | 18.70 | S | ¤ |
| | LM-LI | 18.06 | S | ¤ | 17.23 | S | ¤ |
| Palatal adaptation | Points | T test Fast & Slow cycle (Palatal adaptation) | | | | | |
| | | Stone | | | Silicone | | |
| | | T test | Sig. | Ch. | T test | Sig. | Ch. |
| Shallow | RV | 1.00 | NS | £ | 1.00 | NS | ¤ |
| | RC | 1.00 | NS | ¤ | 1.00 | NS | = |
| | M | 1.00 | NS | £ | 1.00 | NS | ¤ |
| | LC | 1.00 | NS | = | 1.00 | NS | ¤ |
| | LV | 20.36 | S | £ | 1.00 | NS | ¤ |
| Medium | RV | 10.36 | S | £ | 1.00 | NS | ¤ |
| | RC | 1.00 | NS | = | 1.00 | NS | ¤ |
| | M | 18.69 | S | ¤ | 1.00 | NS | ¤ |
| | LC | 30.33 | S | ¤ | 1.00 | NS | ¤ |
| | LV | 17.02 | S | £ | 1.00 | NS | ¤ |
| Deep | RV | 17.66 | S | £ | 20.36 | S | £ |
| | RC | 12.30 | S | £ | 1.00 | NS | = |
| | M | 15.03 | S | £ | 1.00 | NS | = |
| | LC | 30.06 | S | £ | 1.00 | NS | ¤ |
| | LV | 12.47 | S | £ | 1.00 | NS | = |

**Table 6: T-test between stone and silicone investment for curing methods and palatal depths in both teeth movements and palatal adaptation.**

| Teeth movements | Points | T test stone & Silicone (Teeth movement) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Water bath | | | Fast cycle | | | Slow cycle | | |
| | | Ttest | Pvalue | Ch | Ttest | Pvalue | Ch | Ttest | Pvalue | Ch |
| Shallow | M-M | 10.25 | P<0.01 | ¤ | 10.23 | P<0.01 | ¤ | 23.17 | P<0.01 | ¤ |
| | P-P | 10.36 | P<0.01 | ¤ | 15.58 | P<0.01 | ¤ | 15.97 | P<0.01 | ¤ |
| | RM-RP | 1.00 | NS | = | 45.12 | P<0.01 | ¤ | 1.00 | NS | ¤ |
| | RP-RI | 23.65 | P<0.01 | £ | 1.00 | NS | ¤ | 20.14 | P<0.01 | £ |
| | RM-RI | 12.56 | P<0.01 | ¤ | 28.97 | P<0.01 | £ | 17.87 | P<0.01 | £ |
| | LM-LP | 14.25 | P<0.01 | ¤ | 17.98 | P<0.01 | £ | 1.00 | NS | = |
| | LP-LI | 18.98 | P<0.01 | £ | 1.00 | NS | = | 23.54 | P<0.01 | ¤ |
| | LM-LI | 24.28 | P<0.01 | ¤ | 23.35 | P<0.01 | ¤ | 19.24 | P<0.01 | ¤ |
| Medium | M-M | 1.00 | NS | ¤ | 1.00 | NS | = | 22.18 | P<0.01 | £ |
| | P-P | 1.00 | NS | = | 20.13 | P<0.01 | ¤ | 1.00 | NS | = |
| | RM-RP | 26.25 | P<0.01 | ¤ | 15.64 | P<0.01 | £ | 18.47 | P<0.01 | £ |
| | RP-RI | 24.29 | P<0.01 | £ | 41.21 | P<0.01 | ¤ | 20.25 | P<0.01 | ¤ |
| | RM-RI | 19.30 | P<0.01 | ¤ | 23.25 | P<0.01 | ¤ | 1.00 | NS | = |
| | LM-LP | 26.25 | P<0.01 | £ | 20.14 | P<0.01 | £ | 1.00 | NS | ¤ |
| | LP-LI | 24.29 | P<0.01 | ¤ | 11.54 | P<0.01 | ¤ | 28.45 | P<0.01 | £ |
| | LM-LI | 19.30 | P<0.01 | ¤ | 18.97 | P<0.01 | ¤ | 23.45 | P<0.01 | £ |
| Deep | M-M | 1.00 | NS | ¤ | 17.89 | P<0.01 | £ | 10.15 | P<0.01 | ¤ |
| | P-P | 77.23 | P<0.01 | ¤ | 23.24 | P<0.01 | ¤ | 10.24 | P<0.01 | ¤ |
| | RM-RP | 1.00 | NS | = | 18.97 | P<0.01 | ¤ | 11.12 | P<0.01 | £ |
| | RP-RI | 1.00 | NS | ¤ | 23.14 | P<0.01 | ¤ | 11.36 | P<0.01 | £ |
| | RM-RI | 26.25 | P<0.01 | £ | 1.00 | NS | ¤ | 14.15 | P<0.01 | £ |
| | LM-LP | 24.29 | P<0.01 | ¤ | 25.64 | P<0.01 | ¤ | 17.21 | P<0.01 | ¤ |
| | LP-LI | 19.30 | P<0.01 | £ | 1.00 | NS | = | 1.00 | NS | = |
| | LM-LI | 26.25 | P<0.01 | ¤ | 10.25 | P<0.01 | ¤ | 19.32 | P<0.01 | ¤ |

| Palatal adaptation | Points | T test stone & Silicone (Palatal adaptation) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Water bath | | | Fast cycle | | | Slow cycle | | |
| | | Ttest | Pvalue | Ch | Ttest | Pvalue | Ch | Ttest | Pvalue | Ch |
| Shallow | RV | 0 | 1.00 | ¤ | 1.00 | NS | £ | 1.00 | NS | ¤ |
| | RC | 0 | 1.00 | ¤ | 1.00 | NS | ¤ | 1.00 | NS | = |
| | M | 1.00 | NS | = | 1.00 | NS | £ | 1.00 | NS | ¤ |
| | LC | 0 | 1.00 | = | 1.00 | NS | £ | 1.00 | NS | = |
| | LV | 0 | 1.00 | ¤ | 22.31 | P<0.01 | £ | 1.00 | NS | ¤ |
| Medium | RV | 0 | 1.00 | ¤ | 23.04 | P<0.01 | ¤ | 1.00 | NS | ¤ |
| | RC | 0 | 1.00 | ¤ | 25.05 | P<0.01 | ¤ | 1.00 | NS | ¤ |
| | M | 0 | 1.00 | ¤ | 14.45 | P<0.01 | ¤ | 1.00 | NS | ¤ |
| | LC | 0 | 1.00 | ¤ | 47.25 | P<0.01 | ¤ | 1.00 | NS | ¤ |
| | LV | 0 | 1.00 | ¤ | 11.23 | P<0.01 | ¤ | 1.00 | NS | ¤ |
| Deep | RV | 0 | 1.00 | ¤ | 27.65 | P<0.01 | ¤ | 17.89 | P<0.01 | ¤ |
| | RC | 0 | 1.00 | ¤ | 22.35 | P<0.01 | ¤ | 1.00 | NS | ¤ |
| | M | 1.00 | NS | = | 1.00 | NS | = | 10.25 | P<0.01 | ¤ |
| | LC | 0 | 1.00 | ¤ | 18.97 | P<0.01 | ¤ | 1.00 | NS | ¤ |
| | LV | 0 | 1.00 | ¤ | 1.00 | NS | ¤ | 1.00 | NS | ¤ |

## DISCUSSION

The dimensional accuracy of the cured denture base is directly influenced by the topographic structures of the edentulous ridge, which may lead to disturbances in the planned teeth position or even losing the intimate adaptation of the base to the underlying tissues rendering the denture functionally useless. [21]

**For teeth movements**

It expected to occur toward the largest bulk of resin mass, compared with the resin in the palate, so more dimensional changes always occur in the center of the area of higher thickness and this explain the teeth movements in that directions. [5]

**For palatal adaptation**:

Dimensional changes tend to pull the flanges toward each other leading to tensile stress on the molar teeth that will contact the mold and distortion. these forces were divided into vertical and transverse one, which is high in relation to the small surface area of deep palate and will pull the resin mass toward the center of the palate leading to high volume of the mass in that area and increase the thickness and so the amount of the gap space will be more in the deep palate than the medium and shallow one. [22]

**Curing methods:**

During water bath curing, the resin base is not homogeneously cured due to variations in flasks proximity from the curing source. So the curing is not evenly completed and the dimensional inaccuracies increased. [23] Also, when acrylic were cured by water bath; first at 74°C and 90 minutes, the temperature were less than glass transition temperature of acrylic resin, so, after it was left to cool at room temperature, internal stresses will be created. [24,25] then, when curing were finished, at 100°C and 30 minutes, the internal stresses will be released.[26] which will be more exaggerated after flask opening.[27]

The autoclave curing resulted in better stability when compared with water bath due to that autoclave provide even heat spreading and more cross linking between the polymer chains with better opportunity for complete polymerization. [28] On the other hand, the excess temperature occupied by pressure exerted with autoclave leads to faster rate of polymerization. So no residual monomer will resulted, with less chance of dimensional inaccuracies. [29]

Autoclave curing time influenced dimensional stability. Slow curing leads to increase in the dimensional accuracies. The reason for that is: resin curing leads to heat generation which will be further increased by curing machine heat, so there will be complete polymerization of the resin mass exhausting the residual monomer. [28,29] And when the time of curing increased, the resin approach the solidification temperature; glass transition temperature (Tg), resulting in less dimensional changes at the time of flask opening. [25]

**Investment materials**

The stone is difficult investment during deflasking, in addition to high stress during curing leads to strain due to stress release. Also, curing in water bath leads to water sorption of stone and volumetric expansion combined with setting one. While, the coefficient of thermal expansion for stone is less than that of acrylic resin, so space will be formed below the base. [30] On the other hand, the acceptable tear strength of silicone during deflasking, made it better and simpler investing medium to deal with, so sharp knife will be sufficient during denture retrieving without the need for excessive force. [31]

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