10.5005/jp-journals-10024-1240

ORIGINAL RESEARCH

A Comparative Evaluation of the Dimensional Accuracy of Heat Polymerized Acrylic Resin Denture Base Clamped by the Conventional Method and by New-press Technique and Cured by Long Curing Cycle: An *in vitro* Study

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ABSTRACT

Aim: The aim of this study is to evaluate the dimensional accuracy of heat polymerized acrylic resin denture base clamped by the conventional method and by new-press technique and cured by long curing cycle.

Materials and methods: In this study, a total of 60 standardized maxillary record bases were fabricated with seven reference points as follows:

- Point A: Incisive papilla,
- Point B and C: Canine region on either side
- Point E and G: Midpoint of tuberosities on either side
- Point F: Midpoint of the line joining the two tuberosities
- Point D: Midpoint between the line joining A and F

Group A: Ten maxillary record bases were fabricated by conventional clamping method and cured by long curing cycle. **Group A′**: Ten maxillary record bases were fabricated by New Press or RS tension clamping method and cured by long curing cycle.

The distances between the reference points, i.e. A-B, A-C, A-D, D-F, B-E, C-G, E-F, F-G, B-D, D-G, C-D, D-E of all three thermoplastic denture base plates were measured and recorded with the help of travelling microscope and were used for comparison with the measured and recorded readings of processed acrylic denture bases. The data obtained was analyzed by using the one-way analysis of variance and HSD Multiple Comparison Test.

Results: The overall results of the study indicate that among all the denture bases cured by the two clamping systems and the long curing cycle, group A' were the most dimensionally stable, followed by control group A.

Conclusion: The study concluded that the denture bases fabricated by the New Press method using the long curing cycle would produce the most dimensionally stable denture bases.

Keywords: Long-curing cycle, New-press, Tension plate clamping.

How to cite this article: Shankar T, Gowd S, Ahmed ST, Vinod V, Goud MV, Rao NV. A Comparative Evaluation of the Dimensional Accuracy of Heat Polymerized Acrylic Resin Denture Base Clamped by the Conventional Method and by New-press Technique and Cured by Long Curing Cycle: An *in vitro* Study. J Contemp Dent Pract 2012;13(6):842-849.

Source of support: Nil

Conflict of interest: None declared

INTRODUCTION

Polymethylmethacrylate (PMMA) has become the most used material for denture bases since its introduction in 1937. It has excellent esthetic properties, adequate strength, low water sorption, low solubility, lack of toxicity and can be constructed by simple molding and processing technique.[1] A certain lack of dimensional accuracy as of dimensional change in denture base, has been accepted as one of its prime disadvantages. This dimensional change in the denture base can be influenced by polymerization shrinkage, the resin flasking method and time-temperature correlation during the polymerization procedure.[2,3]

When the acrylic resin flasking procedure is performed under routine laboratory conditions, the flask is placed in traditional clamps after final pressing in hydraulic press. This condition may lead to release of residual internal stresses from the acrylic resin dough before polymerization. The release of residual internal stress along with polymerization shrinkage, thermal contraction during flask cooling and strain accompanying stress release during deflasking may cause diminished adaptation of the denture to the tissues.[4]

Rafael and Saide introduced an improved processing technique (New-Press Technique) with the help of RS tension plate clamping, which proved to decreases the magnitude of this gap.[7]

Earlier studies,[7] measured the adaptability of the bases with the cast, only in the posterior palatal region and the fact being that the dimensional changes in the denture base happens overall, a study only in one area would not justify the results. The dimensional accuracy of the denture bases processed by different clamping methods, in different areas and in different directions has not been extensively studied.

The purpose of this study was to investigate the dimensional accuracy of denture bases processed with the conventional heat-polymerizing acrylic resin and the New-Press Technique (Rafael and Saide) by means of long-curing cycle in different areas and different directions.

MATERIALS AND METHODS

The materials and methods used in this study have been described in the following order:

1. Heat polymerizing acrylic resin (DPI Heat Cure)™, Dental products of India Ltd., Batch No 6103).
2. Thermoplastic sheet 5 × 5″, 4 mm thickness (Ultradent) for making standard denture base plate (Fig. 1).
3. Transparent thermoplastic sheet 5 × 5″, 2 mm thick for making transfer template (Fig. 2).

Fig. 1: Thermoplastic sheet

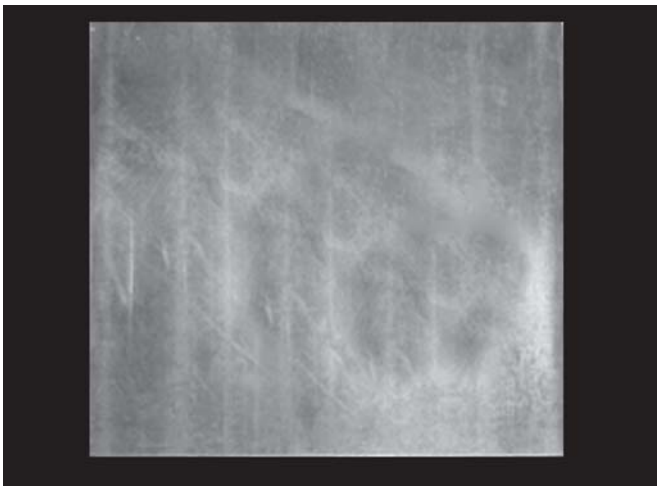


Fig. 2: Transparent thermoplastic sheet

4. Metallic Edentulous maxillary cast made up of Aluminum (Fig. 3).
5. Petroleum jelly (Medi Soft).

Fabrication of Thermoplastic Denture Base Plate

A 4-mm thick thermoplastic sheet was vacuum pressed over the metallic edentulous maxillary cast (Fig. 4). One thermoplastic denture base plate (SP1) was fabricated (Fig. 5).

Fabrication of Thermoplastic Transfer Template

A 2-mm thick transparent thermoplastic sheet was vacuum pressed over the thermoplastic denture base plate placed over the metallic edentulous maxillary cast (Fig. 6).

Fabrication of RS Tension Plates

The assembly consisted of 2 iron plates, each of dimensions 150 × 40 × 8 mm with two screws (9 mm dia) soldered into the centre of each end of one plate (Fig. 7), and was named the lower plate. Two corresponding holes (10 mm dia) were drilled on another plate which formed the upper plate. During the definitive flask closure in the hydraulic bench press, the screws of the lower plate were fit into the holes of upper plate and after obtaining an adequate pressure of 1200 lbs, the screw nuts were strongly tightened. This procedure maintained constant metal to metal contact on the flask halves (Fig. 8).

Marking of Points on the Thermoplastic Denture base Plate and Transfer Template

Seven reference points were marked on the thermoplastic denture base plate SP1 (Fig. 9) with the help of 0.5 mm tip permanent marking pen.

- *Point A:* Incisive papilla.
- *Point B and C:* Canine region on either side.
- *Point E and G:* Midpoint of tuberosity on either side
- *Point F:* Midpoint of the line joining the two tuberosity
- *Point D:* Midpoint between the line joining A and F.

The transparent thermoplastic transfer template was placed over the marked thermoplastic denture base plate and both were together kept on the metallic maxillary edentulous cast (Fig. 10). The whole assembly was placed on the adjusting table of the milling machine (Girrbach, Germany) and was made parallel to the platform of the milling machine. Holes were drilled on to the transparent transfer template and the thermoplastic base plate SP1 with the help of 0.5 mm round diamond point (Fig. 11).

The distances between the reference points, i.e. A-B, A-C, A-D, D-F, B-E, C-G, E-F, F-G, B-D, D-G, C-D, D-E

Fig. 3: Metallic eden mold

Fig. 6: Transparent transfer plate

Fig. 4: Vacuum pressed thermoplastic sheet

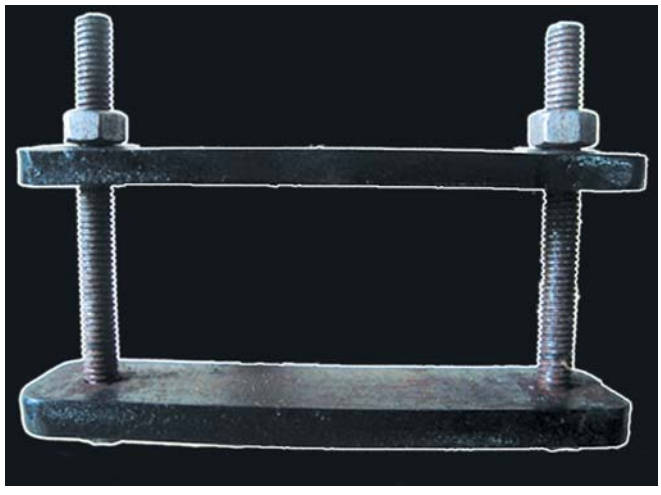


Fig. 7: RS tension plate assembly

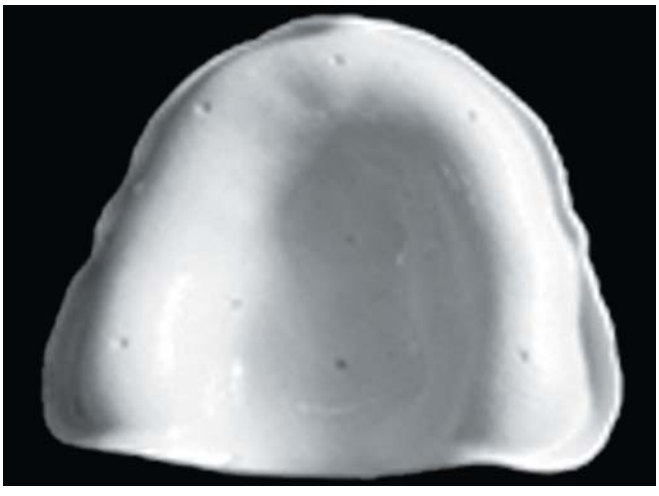


Fig. 5: Thermoplastic denture baseplate

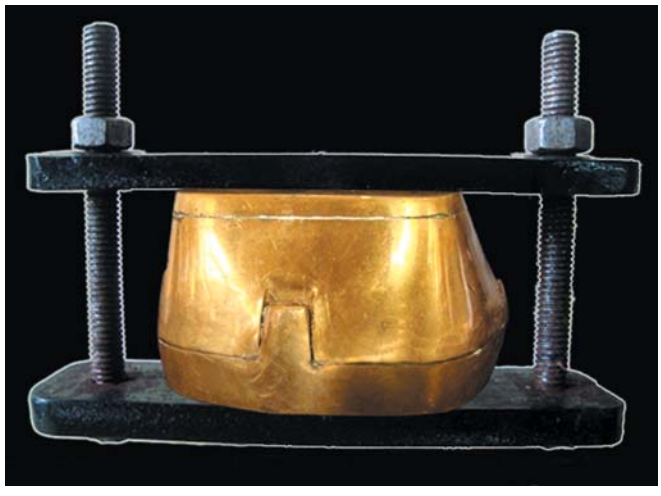


Fig. 8: RS tension plate assembly with flask

of all three thermoplastic denture base plates were measured and recorded with the help of traveling microscope and were used for comparison later with the processed acrylic denture bases (Fig. 12).

Method of Fabrication of Acrylic Denture Bases

Group A: Ten standardized maxillary denture bases were fabricated by conventional clamping method cured by long-curing cycle (74°C for 8 hours).[8]

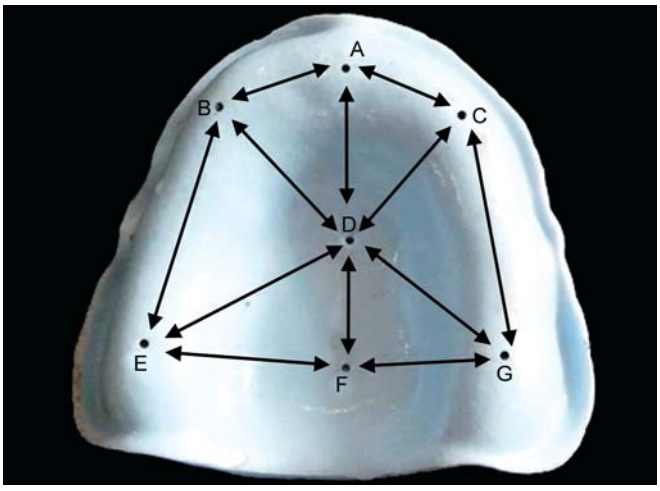


Fig. 9: Reference points on SP1

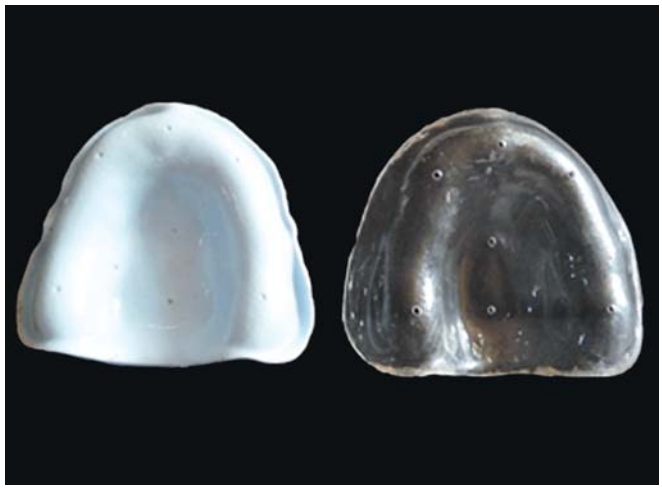


Fig. 11: Markings on SP1 and transfer template

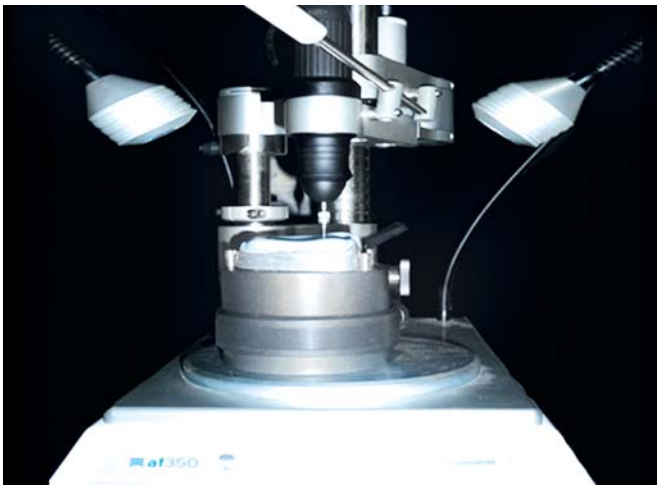


Fig. 10: Milling machine

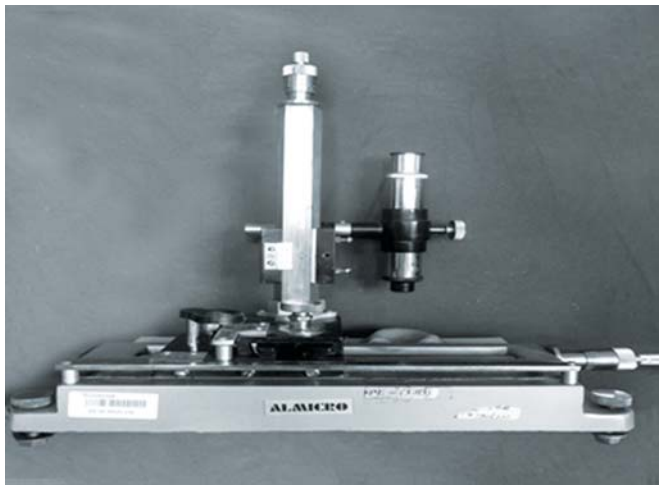


Fig. 12: Traveling microscope

Group A′: Ten standardized maxillary record bases were fabricated by RS Tension[7] clamping method/New-Press Technique cured by long curing cycle.[7]

Measuring the Denture Bases

The processed denture bases (A, A′) were stored in distilled water for 7 days and then the distances between the following points (A-B, A-C, A-D, D-F, B-E, C-G, E-F, F-G, B-D, D-G, C-D, D-E) were measured and recorded using a traveling microscope.

Statistical Analysis of the Data

All the 20 denture bases were measured, readings were obtained, and data was tabulated. These readings were compared with the standard denture base plate readings, i.e. A and A′ with SP1 was done and analyzed with the help of one-way ANOVA test and HSD multiple comparison test.

RESULTS

Table 1 shows one-way analysis of variance (ANOVA) was used to analyze the mean distances between all 7 points on SP1, A and A‘, p-value (<0.0005) was found very highly significant at all distances between the two groups.

Table 2 shows that HSD multiple comparison test was used to analyse the mean distances between all 7 points between the groups SP1 and A, SP1 and A′ and A and A′. p-value (<0.0005) was found very highly significant at distances C-G, E-F, F-G, D-G.

DISCUSSION

Heat activated acrylic denture base resins have been used for over half a century for its excellent esthetics and physical properties. The ease with which methylmethacrylate resins can be processed has made them the material of choice in complete denture fabrication.

In PMMA resins, a certain lack of dimensional accuracy has been accepted as one of its prime disadvantages. This

Table 1: Comparison of SP1, A, A' at various distances by one-way ANOVA test

		Mean	Std. deviation	Min.	Max.	p
A-B	Sp1	15.400	0.0067	15.4	15.4	<0.0005
	A	15.364	0.0084	15.4	15.4	
	A′	15.380	0.0133	15.4	15.4	
A-C	Sp1	15.8940	0.00843	15.88	15.90	<0.0005
	A	15.8480	0.00789	15.84	15.86	
	A′	15.8600	0.0	15.86	15.86	
A-D	Sp1	23.00	0.007	23	23.0	<0.0005
	A	22.97	0.017	23	23.0	
	A′	22.99	0.017	23	23.0	
D-F	Sp1	15.700	0.0067	15.7	15.7	<0.0005
	A	15.628	0.0103	15.6	15.6	
	A′	15.634	0.0084	15.6	15.6	
B-E	Sp1	29.082	0.0140	29.1	29.1	<0.0005
	A	29.000	0.0133	29.0	29.0	
	A′	29.010	0.0094	29.0	29.0	
C-G	Sp1	29.694	0.0084	29.7	29.7	<0.0005
	A	29.598	0.0169	29.6	29.6	
	A′	29.630	0.0133	29.6	29.6	
E-F	Sp1	23.5000	0.00667	23.49	23.51	<0.0005
	A	23.4380	0.00422	23.43	23.44	
	A′	23.4380	0.02150	23.40	23.46	
F-G	Sp1	24.5960	0.00516	24.59	24.60	<0.0005
	A	24.4920	0.01687	24.48	24.52	
	A′	24.5100	0.00943	24.50	24.52	
B-D	Sp1	23.1500	0.00667	23.14	23.16	<0.0005
	A	23.0720	0.03910	23.00	23.10	
	A′	23.0960	0.00843	23.08	23.10	
D-G	Sp1	29.0000	0.00667	28.99	29.01	<0.0005
	A	28.9240	0.01578	28.90	28.94	
	A′	28.9400	0.01333	28.92	28.96	
C-D	Sp1	21.8940	0.00843	21.88	21.90	<0.0005
	A	21.7340	0.00843	21.72	21.74	
	A′	21.7600	0.01886	21.74	21.78	
D-E	Sp1	27.7500	0.00667	27.74	27.76	<0.0005
	A	27.5400	0.01333	27.52	27.56	
	A′	27.6600	0.02667	27.62	27.68	

Table 2: Comparison of SP1-A, SP1-A′, and A-A′ at various distances by HSD multiple comparison test

			Mean difference	p-value
A-B	Sp1	A	0.0360	<0.0005
		A′	0.0200	<0.0005
	A	A′	–0.0160	0.003
A-C	Sp1	A	0.04600	<0.0005
		A′	0.03400	<0.0005
	A	A′	–0.01200	0.001
A-D	Sp1	A	0.028	<0.0005
		A′	0.008	0.434
	A	A′	–0.020	0.011
D-F	Sp1	A	0.0720	<0.0005
		A′	0.0660	<0.0005
	A	A′	–0.0060	0.280
B-E	Sp1	A	0.0820	<0.0005
		A′	0.0720	<0.0005
	A	A′	–0.0100	0.188
C-G	Sp1	A	0.0960	<0.0005
		A′	0.0640	<0.0005
	A	A′	–0.0180	0.005
E-F	Sp1	A	0.06200	<0.0005
		A′	0.06200	<0.0005
	A	A′	0.0320	<0.0005
F-G	Sp1	A	0.10400	<0.0005
		A′	0.08600	<0.0005
	A	A′	–0.0260	<0.0005
B-D	Sp1	A	0.07800	<0.0005
		A′	0.05400	<0.0005
	A	A′	–0.02400	0.074
D-G	Sp1	A	0.07600	<0.0005
		A′	0.06000	<0.0005
	A	A′	–0.01600	0.022
C-D	Sp1	A	0.16000	<0.0005
		A′	0.13400	<0.0005
	A	A′	–0.01100	00.020
D-E	Sp1	A	0.21000	<0.0005
		A′	0.09000	<0.0005
	A	A′	–0.12000	<0.0005

dimensional change in the denture base can be influenced by polymerization shrinkage, the resin flasking method and time–temperature correlation during the polymerization procedure.

When PMMA resin is mixed at recommended polymer: monomer ratio; density of the mass changes from 0.94 to 1.19g/cm^3. This change in density results in volumetric shrinkage of 7% and a corresponding linear shrinkage of 2%. The greater the linear shrinkage the greater the discrepancy observed in the initial fit of the denture. In a study Dixon et al[9] reviewed the properties of denture base polymers and concluded that linear shrinkage generally is observed to be less than 1%.

When the acrylic resin flasking procedure is performed by conventional method, the flask is placed in traditional clamps after final pressing in a hydraulic press. This condition may lead to the release of residual internal stresses from the acrylic resin dough before polymerization. The release of residual internal stress along with polymerization shrinkage, thermal contraction during flask cooling and strain accompanying stress release during deflasking may cause diminished adaptation of the denture to the tissues.[6]

An alternative technique was recognized by Rafael and Saide[6], and they introduced an improved processing technique (New Press Technique) with the help of RS tension plate clamping, which proved to decrease the magnitude of the gap between the denture base and the tissue surface. This system suggests that the RS Tension plates maintained the acrylic dough under constant flask pressure conditions because the flask halves remained firmly in contact when the flask was removed from the hydraulic press. This condition inhibits the premature release of the residual internal stresses from the acrylic resin dough before polymerization shrinkage.

Glass transition temperature of a polymer is an important physical property which may have a major effect on the dimensional stability of denture base materials. Jerolimov V et al[7] investigated variations in glass transition temperature

in different curing cycles using thermo mechanical analysis and they concluded that different curing cycles produced variations in glass transition temperature of up to 20°C, and these variations resulted in polymerization shrinkage.

Therefore, polymerization shrinkage, flask clamping method and time temperature correlation play a critical role in decreasing the probability of unfavorable dimensional changes in acrylic based denture base resins.

In this study, a total of 20 standardized maxillary record bases were fabricated with seven reference points. Twenty maxillary record bases were fabricated by conventional clamping method, out of which 10 Acrylic denture bases were cured by long curing cycle (Group A) in conventional clamping technique and 10 Acrylic denture bases were cured by long curing cycle (Group A') by New Press or RS tension clamping method.

The distances between the reference points, i.e. A-B, A-C, A-D, D-F, B-E, C-G, E-F, F-G, B-D, D-G, C-D, D-E of all three thermoplastic denture base plates were measured and recorded with the help of traveling microscope and were used for comparison with the measured and recorded readings of processed acrylic denture bases. The data obtained was analyzed by using the one-way analysis of variance and HSD multiple comparison test.

The comparative results of thermoplastic denture base plate SP1(control) (Table 3) and denture bases cured by long curing cycle using conventional method and New press method, i.e. A and A′ respectively (Table 4), using one-way ANOVA showed that the p value (<0.0005) was very highly significant at all 12 distances, i.e. A-B, A-C, A-D, D-F, B-E, C-G, E-F, F-G, B-D, D-G, C-D, D-E between the two groups (see Table 1). It is concluded that the denture bases fabricated by New Press method were dimensionally more stable when compared to those fabricated with conventional method. This is in accordance with the previous study done by Consani RLX, Domitti SS, Consani S[6] who studied the effect of New Press system on the dimensional stability of denture bases. They suggested that New Press system is able to produce a more accurate denture base, minimizing the inaccuracies associated with the conventional clamping technique.

The multiple comparison test between thermoplastic denture base plate SP1(control) and denture bases cured by long curing cycle using conventional method (A) and New press method (A′) showed that the p value (<0.0005) was very highly significant at all the 12 distances A-B, A-C, D-F, B-E, C-G, E-F, F-G, B-D, D-G, C-D, D-E, A-D. The multiple comparison between A and A′, showed that p-value (<0.0005) was very highly significant only at three distances, i.e. E-F, F-G and D-E and other nine distances were not significant ($p > 0.05$). This shows that the denture bases fabricated by long curing cycle and New Press method (C′) were dimensionally more stable than the denture bases fabricated by conventional method using long curing cycle (C).

The clamping method (New Press/conventional method) had the least impact on the dimensions of the denture bases cured by long curing cycle with only 3 distances showing significant changes.

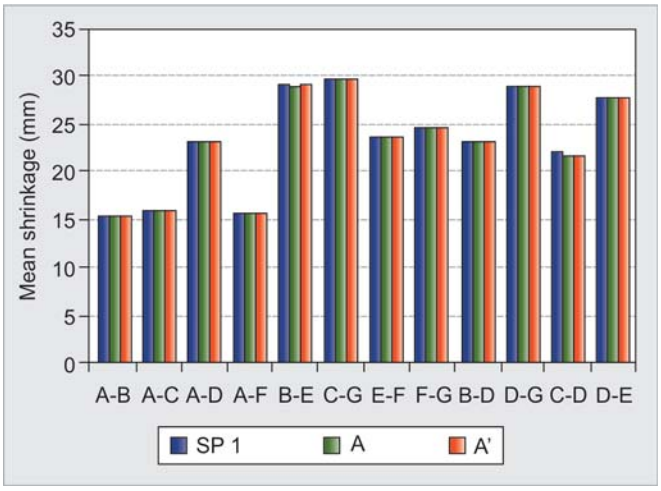
The mean value of the total of all the distances between the points, of standard denture base plate SP1was 23.219 mm. When compared to this, the similar mean value of group A′ was 23.159 mm which shows that there was an overall shrinkage of 0.060 mm. This was the least among

Table 3: Average readings of standard denture base plates SP1

	A-B	A-C	A-D	D-F	B-E	C-G	E-F	F-G	B-D	D-G	C-D	D-E
SP1	15.40	15.95	23.00	15.70	29.10	29.70	23.55	24.56	23.13	29.05	21.86	27.74
	15.39	15.93	22.98	15.68	29.08	29.68	23.54	24.59	23.12	29.04	21.88	27.75
	15.40	15.95	22.97	15.67	29.10	29.70	23.55	24.58	23.13	29.05	21.88	27.74
	15.38	15.94	23.00	15.70	29.06	29.69	23.53	24.59	23.14	29.03	21.87	27.73
	15.40	15.95	23.00	15.70	29.10	29.70	23.55	24.57	23.13	29.05	21.88	27.72

Table 4: Average readings of processed acrylic denture bases A and A′

	A-B	A-C	A-D	D-F	B-E	C-G	E-F	F-G	B-D	D-G	C-D	D-E
A	15.364	15.848	22.972	15.628	29.00	29.598	23.438	24.492	23.072	28.924	21.734	27.54
	15.36	15.86	22.96	15.64	29.02	29.58	23.44	24.48	23.00	28.92	21.74	27.52
	15.36	15.84	22.96	15.62	29.00	29.58	23.43	24.48	23.08	28.94	21.74	27.54
	15.36	15.85	22.98	15.62	29.00	29.60	23.44	24.50	23.08	28.92	21.73	27.56
A′	15.38	15.86	22.992	15.634	29.01	29.63	23.438	24.51	23.096	28.94	21.76	27.66
	15.36	15.86	23.00	15.64	29.00	29.64	23.44	24.50	23.10	28.92	21.74	27.62
	15.38	15.86	22.96	15.63	29.02	29.61	23.45	24.50	23.08	28.94	21.78	27.64
	15.38	15.86	23.00	15.64	29.00	29.62	23.44	24.51	23.10	28.96	21.78	27.68



Graph 1: Comparison of SP1, A and A′

the groups, proving that the denture bases fabricated by the New Press method and long curing cycle demonstrated least shrinkage (Graph 1). The group A showed a mean value of 23.134, which showed 0.085 mm shrinkage. This shows that the denture bases fabricated by long curing cycle were the most dimensionally stable followed by the denture bases fabricated by short curing cycle and the denture bases fabricated by fast curing cycle being the least stable. This is because the long curing cycle is a well-controlled process which avoids the effects of uncontrolled temperature rise, boiling of monomer, denture base porosity and associated polymerization shrinkage, when compared to other two cycles. This is in accordance with the study done by Honorez P et al[10] who studied the effects of three processing cycles on some physical and chemical properties of heat cure acrylic resins and concluded that long curing cycle had resulted in low residual monomer content thereby indicating low polymerization shrinkage when compared to other two curing cycles.

On overall analysis of data it was concluded that distance A-D (anterior slope of the palate) was the most dimensionally stable distance and distances E-F and F-G (posterior palatal area) were least dimensionally stable distances in all the groups. The reason for A-D being most dimensionally stable could be the presence of rugae which would impede the linear shrinkage due to better adaptability of the acrylic denture base to the underlying cast surface and the reason for E-F and F-G being least dimensionally stable is the large unsupported posterior palatal area this is in accordance with the previous study done by Firtell DN et al[5] who studied the distortion in posterior peripheral seal area related to processing temperature and concluded that the greatest effect of linear shrinkage on a maxillary denture is usually on the posterior palatal area, resulting in space between the palatal portion of the cast and the processed denture.

It can be concluded that the denture bases fabricated by the New Press method using the long curing cycle would produce the most dimensionally stable denture bases.

CONCLUSION

Within the limits of the present study and on the basis of results obtained, it may be concluded that:

1. The denture bases fabricated by New Press method were dimensionally more stable when compared to those fabricated by conventional method.
2. In all the fabricated denture bases, the distance A-D, i.e. the anterior slope of the palate was the most dimensionally stable region.
3. In all the fabricated denture bases, the distance E-F and F-G, i.e. the posterior palatal seal area was the least dimensionally stable region.

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