

# International Journal of Dental Science and Innovative Research (IJDSIR) **IJDSIR** : Dental Publication Service Available Online at: www.ijdsir.com Volume – 3, Issue – 1, January - 2020, Page No. : 170 - 177 Comparison of dimensional changes of Compression molded vs Injection molded heat-cured resin with different thicknesses <sup>1</sup>Dr. Rupal J. Shah, Professor and Head of Department, Department of Prosthodontics, Govt. Dental College & Hospital, Ahmedabad, Gujarat - 380016, India <sup>2</sup>Dr. Sanjay B. Lagdive, Professor, Department of Prosthodontics, Govt. Dental College & Hospital, Ahmedabad, Gujarat - 380016. India <sup>3</sup>Dr. Abhay H. Machchhar, 3rd year Post-graduate student, Department of Prosthodontics, Govt. Dental College & Hospital, Ahmedabad, Gujarat - 380016, India <sup>4</sup>Dr. Sherin Cherian, 3rd year Post-graduate student, Department of Prosthodontics, Govt. Dental College & Hospital, Ahmedabad, Gujarat - 380016, India <sup>5</sup>Dr. Kalaiarasi Periyanan, 1<sup>st</sup> year Post-graduate student, Department of Prosthodontics, Govt. Dental College & Hospital, Ahmedabad, Gujarat - 380016, India Corresponding Author: Dr. Abhay H. Machchhar, 3rd year Post-graduate student, Department of Prosthodontics, Govt. Dental College & Hospital, Ahmedabad, Gujarat – 380016, India Citation of this Article: Dr. Rupal J. Shah, Dr. Sanjay B. Lagdive, Dr. Abhay H. Machchhar, Dr. Sherin Cherian, Dr. Kalaiarasi Periyanan, "Comparison of dimensional changes of Compression molded vs Injection molded heat-cured resin with different thicknesses", IJDSIR- January - 2020, Vol. - 3, Issue -1, P. No. 170 - 177. Copyright: © 2020, Dr. Abhay H. Machchhar, et al. This is an open access journal and article distributed under the terms of the creative commons attribution noncommercial License. Which allows others to remix, tweak, and build upon the work non commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms. **Type of Publication:** Original Research Article **Conflicts of Interest: Nil**

### Abstract

Injection molding technique is known to produce more accurate dentures as compared to conventional compression molding procedure. The aim of the study was to compare dimensional accuracy of injection molding samples and compression molding samples of different thicknesses. SR-Ivocap High Impact resin was used for injection molding and SR-Ivocap Triplex Hot resin was used for conventional compression molding technique. All the specimens were stored in distilled water until measured. Measurements were taken at 24 hr, 48 hr and 7 days. For dimensional accuracy measurement, a digital caliper with 0.01 mm accuracy was used. Statistical analysis was carried out using one-way ANOVA and repeated-measures ANOVA in SPSS software with statistical significance (p) defined at 5 %. After each water storage, injection-molded samples had less dimensional shrinkage as compared to compression molded samples of 1.5 and 2.5 mm thickness. 2.5 mm injection molded samples exhibited minimum dimensional change and 3.5 mm compression molded samples exhibited minimum dimensional change. Within limitations of this study,

molding technique and thickness had effect on dimensional stability of SR-Ivocap acrylic resin. Injection molding technique samples had less dimensional changes as compared to compression molding samples of 1.5 and 2.5 mm thickness. The thickness of acrylic resin has a significant effect on dimensional accuracy.

**Keywords:** Compression molding, Dimensional accuracy, Injection molding.

### Introduction

Since its introduction in dentistry, acrylic resin is the most common denture base material in clinical use.<sup>[1&2]</sup> Polymethyl methacrylate (PMMA) is most commonly used for fabrication of dentures.<sup>[2]</sup> Good esthetic and physical properties with low biological toxicity as compared with other polymers make these materials excellent choice for intraoral use.<sup>[3]</sup> Conventional method for denture processing is compression molding with heat activation in water bath.<sup>[4]</sup> However, polymerization shrinkage and dimensional changes after processing of denture base resin are unavoidable and well documented.<sup>[3]</sup> These changes decrease the close adaptation of denture to tissue surface leading to misfit of the denture.<sup>[5]</sup> Hence, acrylic resin and its processing techniques have been modified to enhance physical and mechanical properties.

To overcome undesirable properties of compression molding, Pryor, in 1942, introduced injection molding technique.<sup>[6]</sup> Grunewald et al, in 1952, reported no significant advantage of Pryor's technique over conventional compression molding.<sup>[7]</sup> In 1970, Ivoclar (Schaan, Liechtenstein) introduced an injection molding system and modified acrylic resin to be used for the injection molding process.<sup>[8&9]</sup> This powder liquid system consist of a premeasured methyl methacrylate liquid and powder which is mixed mechanically and injected under continuous pressure throughout the processing. This

continuous injection of resin compensates for the polymerization shrinkage. The processing is done in a thermostatically controlled water bath. This technique produces more dimensionally stable denture.<sup>[10]</sup>

There are many injection molded resins and techniques available now, and each claim to produce more dimensionally accurate dentures.<sup>[11]</sup> In fabricating complete dentures, Ivoclar acrylic resins are valuable.<sup>3</sup> The thickness of acrylic is a significant factor for dimensional accuracy of processed resin.<sup>[12&13]</sup> The aim of this study was to compare the dimensional accuracy of rectangular Ivoclar resin samples fabricated by conventional processing verses the SR-Ivocap injection molding technique with three different thicknesses.

#### **Materials and Method**

In this study, dimensional accuracy of acrylic resin processed by compression molding technique (SR-Ivocap Triplex Hot resin, Ivoclar Vivadent, Liechtenstein) was compared to injection molding technique (SR-Ivocap High Impact, Ivoclar Vivadent, Liechtenstein) with 3 different thicknesses viz 1.5 mm, 2.5 mm and 3.5 mm.



Fig 1: Magnetic ferrite block as master die Six rectangular magnetic ferrite blocks of  $24 \times 26 \times 10$ mm (Fig 1) were fabricated to prepare 30 samples for each technique. Injection molding samples were divided into

Page L

three subgroups of 1.5 mm, 2.5 mm and 3.5 mm thickness (Fig 2) and the same was done for compression molding. Four depressions of 1 mm in depth were made in each magnetic ferrite master block for index marks (A, B, C and D). To fabricate three different thickness samples (1.5 mm, 2.5 mm and 3.5 mm), modelling wax (Y Dents Modelling wax, MDM corporation, Delhi, India) was adapted on master die and Vernier caliper (Digimatic Vernier caliper, Cobra Metal, India) was used to adjust the thickness of each sample. Type III dental stone (Goldstone, Asian chemicals, Rajkot, Gujarat, India) was mixed according to the manufacturer's recommendation and each master die was flasked.



Fig 2: Three different thickness samples – 1.5, 2.5 and 3.5 mm

For conventional compression molding technique, SR-Ivocap Triplex Hot resin was used. After dewaxing, resin was mixed according to the manufacturer's instructions (10 ml of liquid to 23 g of powder) and packed into the mold. After 30 minutes of bench curing, polymerization was done in boiling water and curing cycle was followed recommended by the manufacturer. After as polymerization, the flasks were bench cooled to room temperature, and the samples were deflasked. The surfaces without reference points were finished with 120-, 300- and 600-grit sandpaper (3M India ltd). All the samples were stored in distilled water at room temperature until measured. Measurements were done at 24 hr, 48 hr and 7 days with a digital Vernier caliper of 0.01 mm accuracy (Digimatic Vernier caliper, Cobra Metal, India). Raised indentations on samples were used as reference points for measurement and marked as letters A, B, C and D. Six

measurements viz AB, BC, CD, AD, AC and BD were recorded for each sample (Fig 3). For each of the six measurements, three measurements were taken and mean was calculated. The dimensional changes in acrylic resin samples were evaluated by measuring the dimensions of master die at fixed reference points and those of acrylic samples. The dimensional changes in acrylic samples were measured according to the study done by Baydas.<sup>[11]</sup> The algebraic norm used the square root of sum of squares of individual dimensions:

Norm=  $\sqrt{AB^2 + BC^2 + CD^2 + AD^2 + AC^2 + BD^2}$ 



Fig 3: Measured dimensions: AB, BC, CD, AD, AC and BD

For injection molding technique, samples were fabricated in specially designed flasks (Fig 4). Premeasured capsules (20 g powder and 30 ml liquid) of SR-Ivocap High Impact were mixed in cap vibrator (Ivoclar vivadent) for 5 minutes prior to injecting into the flask. While injecting resin into the flask, a constant pressure of 6 atm was maintained. Curing was done in boiling water at 100 °C maintaining 6 atm pressure for 35 minutes. A 10 minutes cooling was done under running water maintaining 6 atm pressure which was followed by further 10 minutes

cooling without pressure before deflasking. Then, the samples were deflasked and surfaces without reference points were finished using 120-, 300- and 600-grit sandpaper (3M India ltd). All the acrylic samples were stored in distilled water at room temperature until measured. Measurements were recorded at 24 hr, 48 hr and 7 days intervals. For each injection molding acrylic sample, the algebraic norm was calculated similar to conventional compression molding acrylic samples. Statistical analysis was done in SPSS (SPSS, IBM version 22) using one-way ANOVA and repeated-measures ANOVA. Statistical significance was defined at p<0.05.



Fig 4: Injection molding technique (dewaxing)

#### Results

The norm was determined for each original master die according to the formula:

Norm=  $\sqrt{AB^2 + BC^2 + CD^2 + AD^2 + AC^2 + BD^2}$ 

This value was also calculated for acrylic samples at 24 hr, 48 hr and 7 day intervals after polymerization. The dimensional change was determined based on the difference between these two values. A comparison of dimensional changes in compression molding vs injection molding at 1.5 mm, 2.5 mm and 3.5 mm thickness is summarized in Table I. In general, in both groups, dimensions of acrylic resin samples decreased in

comparison to original magnetic ferrite master die. Table I describes mean values for comparison of two molding techniques used for fabrication of 3 different thickness samples. There was a significant difference in dimensional changes of 1.5 mm, 2.5 mm and 3.5 mm thickness samples fabricated by compression molding and injection molding technique (p<0.05). 1.5 mm and 2.5 mm thick samples had significantly less dimensional change when fabricated by injection molding technique. 3.5 mm thick samples had significantly less dimensional change when processed by compression molding technique. All 3 thickness Injection molding samples showed slight shrinkage at 48 hr followed by expansion at 7 day which was statistically significant (p<0.05)(Table II). All 3 thickness compression molding samples showed variable shrinkage and expansion at 48 hr and 7 day intervals which was statistically not significant (p>0.05)(Table III). In injection molding technique, minimum dimensional changes were observed for 2.5 mm thickness samples and maximum dimensional changes for 3.5 mm thickness samples. In compression molding technique, minimum dimensional changes were observed for 3.5 mm thickness samples and maximum dimensional changes were observed for 1.5 mm thickness samples. Injection molding: Shrinkage - 3.5 > 1.5 > 2.5 mm. Compression molding: Shrinkage - 1.5 > 2.5 > 3.5 mm.

Table I: Comparison of two molding techniques at 3 different thicknesses

Injection molding vs	Mean difference	P Value
Compression molding	(in mm)	
1.5 mm thickness	0.52	0.02
2.5 mm thickness	0.78	< 0.001
3.5 mm thickness	-1.22	< 0.001

Table II: Time wise comparison of mean dimension valuesfor injection molding technique at different thickness

Page L

Thislanson	24 hrs	48 hrs	7 days	D Value
THICKNESS	(in mm)	(in mm)	(in mm)	P value
1.5 mm	40.23 ±	40.07 ±	40.36 ±	0.02
(n=10)	0.38	0.34	0.57	0.02
2.5 mm	41.36 ±	$40.97 \hspace{0.2cm} \pm \hspace{0.2cm}$	41.35 ±	<0.001
(n=10)	0.39	0.33	0.44	<0.001
3.5 mm	$39.65 \pm$	39.31 ±	39.61 ±	0.01
(n=10)	0.54	0.41	0.57	0.01

Table III: Time wise comparison of mean dimension values for compression molding technique at different thickness

Thickness	24 hrs	48 hrs	7 days	P Value
THICKHESS	(in mm)	(in mm)	(in mm)	r value
1.5 mm	39.69 ±	39.62 ±	39.78 ±	0.20
(n=10)	1.00	0.92	0.80	0.29
2.5 mm	40.45 ±	40.49 ±	40.39 ±	0.63
(n=10)	0.45	0.48	0.44	0.05
3.5 mm	40.79 ±	40.75 ±	40.69 ±	0.48
(n=10)	0.72	0.58	0.69	0.48

### Discussion

The present study observed the dimensional changes that occur in acrylic resins processed by two different curing techniques - compression molding and injection molding. In particular the effect of variables like thickness and water sorption were studied.

Conventional compression molding is known for its unsophisticated technique and reasonably good accuracy. This technique is most commonly practiced and also considered as gold standard for comparison with other techniques.<sup>[14]</sup> Pryor stated the injection molding technique and claims that it reduces processing errors and increases the resin density due to pressure exerted during injection of acrylic resin into the mold.<sup>[6 & 9]</sup>

As mentioned by Wolfaardt, dimensional changes are affected by a variety of factors<sup>[15]</sup> such as shape,<sup>[16]</sup> denture thickness,<sup>[17]</sup> different types of denture base resins<sup>[18]</sup> and

presence of teeth.<sup>[19]</sup> In order to study the effect of thickness on the dimensional stability of acrylic resin processed by two different technique, in this study, rectangular magnetic ferrite dies were used to fabricate acrylic specimens of 3 different thicknesses (1.5, 2.5, 3.5 mm). As stated by Salim,<sup>[20]</sup> Baydas<sup>[11]</sup> and Gharechahi<sup>[2]</sup> these uniform rectangular dies enabled us to analyse the property of acrylic resin per se by controlling effect of factors such as shape and presence of teeth.

To determine the dimensional accuracy of denture base resin, different methods have been tried namely, vernier gauges, comparators, micrometers, calipers, and radiography. Digital caliper was used by Garfunkel<sup>[21]</sup> to assess changes in vertical dimension of occlusion and dentures. Lee<sup>[22]</sup> utilized computerized processed tomography scanning to measure gap formation between processed dentures and their respective master casts. Keenan<sup>[23]</sup> used internal micrometer to compare the dimensional changes of simulated maxillary complete dentures with different polymerization techniques. In this study, we have used vernier caliper (Digimatic Vernier caliper, Cobra Metal, India) for determining the dimensional changes. Vernier caliper is readily available and easy to use. The measurement of dimensional change in rectangular samples was made easy by using a mathematical formula as stated by Baydas.<sup>[11]</sup> For this purpose, 4 reference indentations were made in the magnetic ferrite dies, denoted as A, B, C and D. From these points six values were obtained AB, BC, CD, DA, AC, BD and applied in the formula. Salim<sup>[20]</sup> and Baydas<sup>[11]</sup> applied this formula to compare the dimensional accuracy of different processing techniques of acrylic resin.

A large number of studies have correlated different methods of processing acrylic resin but little importance has been given to the different brands of resin and hence its varying composition. Keenan,<sup>[23]</sup> Consani,<sup>[24]</sup> Nogueira<sup>[25]</sup> and Alkhatib<sup>[26]</sup> conducted similar study but variability in composition of material used in both techniques were not controlled. The present study takes control of this variable by utilizing acrylic resin material of the same brand (Ivoclar Vivadent, Liechtenstein) and paves way to observe the dimensional accuracy obtained by two processing techniques.

Denture thickness can largely affect the dimensional stability of acrylic resin.<sup>[15 & 17]</sup> To inspect this physical property, we have used three different thickness of rectangular acrylic samples namely, 1.5 mm, 2.5 mm, 3.5 mm.

The presence of water also affects the dimensional stability of acrylic resin. Goodkind et al<sup>[27]</sup> demonstrated that immersion in water has no significant role in altering the dimensions of denture base. Consani<sup>[24]</sup> observed that 90 days of storage of denture bases in water did not have any influence on linear dimension of distance between teeth considering deflasking period as a variable. Miessi<sup>[28]</sup> stated that soaking in water caused sizable dimensional changes and adaptation problems in denture bases after a period of 180 days. As reported by some authors water storage of acrylic denture bases results in considerable expansion due to water sorption. Water sorption pushes the macromolecules apart and as the result acrylic expands.<sup>[29]</sup> This expansion compensates the polymerization shrinkage of acrylic resin and enhances the adaptation of acrylic resin to basal tissues.<sup>[28]</sup> The results obtained in this study were contradictory to the previous studies by  $Consani^{[24]}$  and in favor of  $Miessi^{[28]}$  and Gharechahi<sup>[2]</sup> as presence of water did affect the dimension of acrylic resin, especially after 48 hours, injection molded resin displayed shrinkage, followed by expansion. The findings in the present study are partly in support with previous studies by Keenan,<sup>[23]</sup> Wolfaardt,<sup>[15]</sup>

Parvizi<sup>[30]</sup> and Gharechahi<sup>[2]</sup> as SR-Ivocap injection molding samples of 1.5 mm and 2.5 mm thickness had significantly less dimensional shrinkage as compared to compression molding technique. But, 3.5 mm thick injection molded samples had more dimensional shrinkage than compression molded samples of same thickness which is contrary to the previously mentioned studies.<sup>[23,15,30,2]</sup> Sykora<sup>[31]</sup> studied that injection molding technique has less dimensional shrinkage because resin particles are small, polymerization temperature is less, and there is no displacement of two halves of flask during packing.

Thus, from the findings of previous and present studies, injection molding technique has less dimensional shrinkage as compared to compression molding technique for 1.5 and 2.5 mm thicknesses.

### Conclusion

Within the limitation of this study, dimensional changes in acrylic resin were influenced by processing techniques and thickness of resin. 1.5 and 2.5 mm thick samples of injection molding (SR-Ivocap High Impact) had more dimensional stability than compression molding technique (SR-Ivocap Triplex Hot). 3.5 mm thick samples processed by compression molding were more dimensionally stable than samples processed by injection molding technique.

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  M. Dimensional Changes of Acrylic Resin Denture

Page

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