Original Article

Dimensional Changes of Acrylic Resin Denture Bases: Conventional Versus Injection-Molding Technique

Jafar Gharechahi[1], Nafiseh Asadzadeh [2], Foad Shahabian[3], Maryam Gharechahi[4]✉

[1]Professor, Dental Research Center, Department of Prosthodontics, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran
[2]Associate Professor, Department of Prosthodontics, Dental Research Center, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran
[3]Assistant Professor, Department of Prosthodontics, Dental Research Center, School of Dentistry, Ahvaz University of Medical Sciences, Ahvaz, Iran
[4]Assistant Professor, Dental Material Research Center, Department of Endodontics, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran

Abstract

Objective: Acrylic resin denture bases undergo dimensional changes during polymeri tion. Injection molding techniques are reported to reduce these changes and thereby prove physical properties of denture bases. The aim of this study was to compare dim sional changes of specimens processed by conventional and injection-molding te niques.

Materials and Methods: SR-Ivocap Triplex Hot resin was used for conventional pr sure-packed and SR-Ivocap High Impact was used for injection-molding techniques. ter processing, all the specimens were stored in distilled water at room temperature u measured. For dimensional accuracy evaluation, measurements were recorded at 24-ho 48-hour and 12-day intervals using a digital caliper with an accuracy of 0.01 mm. Sta tical analysis was carried out by SPSS (SPSS Inc., Chicago, IL, USA) using t-test and peated-measures ANOVA. Statistical significance was defined at P<0.05.

Results: After each water storage period, the acrylic specimens produced by inject exhibited less dimensional changes compared to those produced by the conventic technique. Curing shrinkage was compensated by water sorption with an increase in ter storage time decreasing dimensional changes.

Conclusion: Within the limitations of this study, dimensional changes of acrylic re specimens were influenced by the molding technique used and SR-Ivocap injection p cedure exhibited higher dimensional accuracy compared to conventional molding.

Key words: Acrylic resin; Denture base; Physical processes

Journal of Dentistry, Tehran University of Medical Sciences, Tehran, Iran (2014; Vol. 11, No. 4)

✉ Corresponding author:
M. Gharechahi, Department of Endodontics, Dental Research Center, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran

gharechahim@mums.ac.ir

Received: 16 January 2014
Accepted: 18 June 2014

INTRODUCTION

Acrylic resin polymers have been introduced as denture base materials and the majority of denture bases are fabricated using polymethyl methacrylate (PMMA). These materials have optimal physical properties and excellent esthetics with relatively low toxicity compared to other plastic denture base materials [1].

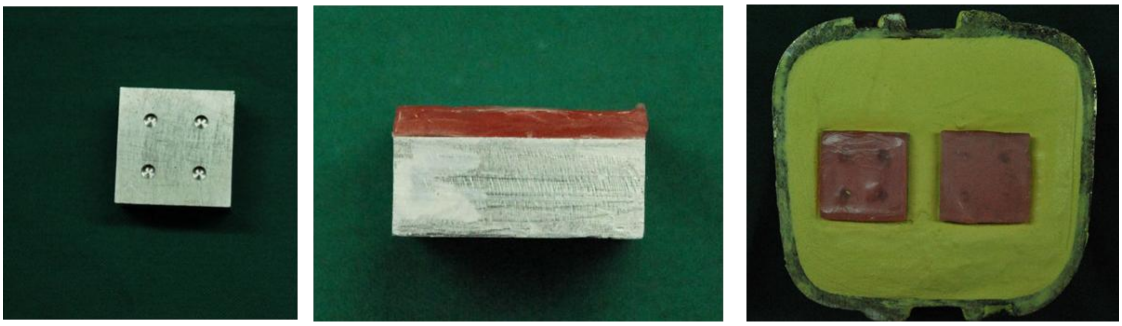

Fig 1. (a): Original specimen made from stainless steel, (b): Two layers of wax placed on stainless steel plates, (c): The plates embedded in a flask

Compression molding with heat activation in a water bath for resin polymerization is the conventional method used to process dentures [2]. However, shrinkage and dimensional changes of denture bases during resin polymerization are inevitable and have been well documented [1]. Such problems associated with compression molding, increase the gap between the denture base and underlying mucosa, compromising the fit of dentures [3]. Therefore, acrylic resins and processing methods have been modified to improve physical and chemical properties of denture bases.

In 1942, Pryor [4] introduced the injection-molding technique to overcome the adverse effects of compression molding. Grunewald et al. [5] investigated Pryor's technique and reported no significant advantages over the conventional method. In 1970, Ivoclar (Schaan, Liechtenstein) introduced an injection-molding system that used an acrylic resin modified for the injection-molding process [6, 7]. This system consists of a premeasured mechanical mixing of methyl methacrylate liquid and powder, injected under continuous pressure throughout the processing procedure to compensate for the expected polymerization shrinkage of the resin. The denture is processed in a thermostatically controlled water bath at 100°C. The entire procedure lasts 55 minutes and is claimed to produce a dimensionally stable denture; which is an exact replica of the denture-bearing area [8].

Several injection-molded denture base materials and processing techniques are now available; each claimed to produce more accurate denture bases [9]. Ivoclar acrylics are among the important resins in complete denture materials [1]. The aim of this study was to compare the dimensional stability of rectangular Ivoclar resin specimens cured by conventional processing versus the SR-Ivocap injection-molding method.

MATERIALS AND METHODS

In this study, the dimensional accuracy of conventional pressure-packed PMMA (SR-Ivocap Triplex Hot, Ivoclar Vivadent, Liechtenstein) was compared to injection-molded PMMA base material (SR-Ivocap High Impact, Ivoclar Vivadent, Liechtenstein).

Dimensional accuracy

Four rectangular stainless steel plates (25 mm × 25 mm × 10 mm) were fabricated to prepare fifteen acrylic resin specimens for each technique. Four holes, measuring 0.5 mm in depth, were engraved in the metal specimens for index marks (the letters A, B, C, and D). Two layers of wax (Cavex, Netherlands) were placed on stainless steel plates and flasked. To embed the flasks, type III dental stone (Herodent; Vigodent, Petropolis, RJ, Brazil) was used and mixed according to the manufacturer's instructions (100 g of powder with 30 mL of water, Figure 1).

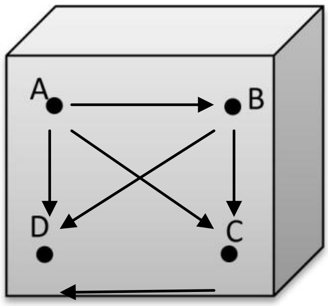

Fig 2. Measured dimensions: AB, BC, CD, AD, AC, and BD mm.

The liquid-to-powder ratio of SR Triplex Hot resin was 10 mL of liquid to 23 g of powder. The acrylic resin was mixed according to the manufacturer's recommendation and packed in the flask. Conventional PMMA specimens were fabricated using a conventional flasking and pressure-pack technique. Polymerization process was performed in boiling water under a pressure of 100 N for 45 minutes. After polymerization, the curing flasks were bench-cooled to room temperature, and the specimens were deflasked. The surfaces without reference points were finished using 800-, 400-, and 200- grit sandpapers (Norton; Saint-Gobain Abrasivos, Brazil).

All the rectangular specimens were stored in distilled water at room temperature until measured. Measurements were recorded at 24-hour, 48-hour, and 12-day intervals with a digital caliper accurate to 0.01 mm (Mitutoyo, Mfg. Co, Tokyo, Japan) by means of raised indentations as reference points. The reference points in each acrylic specimen were designated by letters A, B, C, and D. Six measurements (distances AB, BC, CD, AD, AC, and BD) were recorded for each acrylic specimen (Figure 2).

Five measurements were made for each of the six dimensions and a mean value was calculated. The dimensional changes of acrylic resin specimens were evaluated by measuring the distances between reference points on specimens and the differences between these fixed points and the original stainless steel plates. The dimensional changes in the resin samples were measured according to the study performed by Baydas [9] using a digital caliber. The algebraic norm used the square root of sum of squares of individual dimensions:

$$\text{Norm}= \sqrt{AB2+BC2+CD2+AC2+AD2+BD2}$$

For the injection-molded technique, the specimens were flasked according to the manufacturer's instructions using the Ivocap flask. Premeasured SR-Ivocap capsules of resin and monomer (20 g powder, 30 mL monomer) were mixed in Cap vibrator (Ivoclar AG) for 5 minutes before injecting into the flask. For the curing process of the SR-Ivocap system, hydraulic pressure of 6 atm at 100°C was maintained for 35 minutes. A 10-minute cooling process using running water with a pressure of 6 atm was used before deflasking the denture. Finally, there was a further l0-minute cooling period, but without any extra pressure. Then, the specimens were deflasked and the surfaces without reference points were finished using 800-, 400-, and 200-grit sandpapers (Norton; Saint-Gobain Abrasivos, Brazil). All the rectangular specimens were stored in distilled water at room temperature until measured. Measurements were recorded at 24-hour, 48-hour, and 12-day intervals. For each injection-molded acrylic specimen, the algebraic norm was determined similar to conventional pressure-packed PMMA.

Statistical analysis

Following data collection, statistical analysis was carried out by SPSS (SPSS Inc., Chicago, IL, USA), using the t-test and repeated-measures ANOVA. Statistical significance was defined at $P<0.05$.

RESULTS

The norm was determined for each original stainless steel plate according to the formula:

$$Norm=\sqrt{AB2+BC2+CD2+AC2+AD2+BD2}$$

This value was also calculated for acrylic specimens at 24-hour, 48-hour, and 12-day intervals after curing. The dimensional change was determined based on the difference between these two values.

A summary of dimensional changes in conventional pressure-packed and injection-molded SR-Ivocap groups is shown in Table 1.

In general, in both groups, dimensions of acrylic specimens decreased in comparison to original stainless steel plates. After 24 hours, there was a significant difference between specimens cured by the conventional technique and those cured with the injection method (P=0.002). The specimens cured with the injection method exhibited less dimensional changes.

After both 48 hours and 12 days of storage in distilled water, the specimens cured by injection processing exhibited less dimensional changes compared to those produced by conventional technique (P=0.002).

In order to compare time-dependent dimensional changes in each group, repeated-measures ANOVA was used.

In specimens cured with the conventional method, significant differences in dimensional changes were found between 24-h, 48-h, and 12-day intervals (24 h>48 h>12 days) (P=0.000).

Time-dependent dimensional changes in the injection method were as follows: 48 h> 24 h>12 days. Repeated-measures ANOVA exhibited significant differences in dimensional changes of specimens at 24-h, 48-h, and 12-day intervals (P=0.001).

DISCUSSION

This study evaluated the dimensional stability of rectangular specimens produced using injection-molding and compression-molding techniques with thermally activated PMMA resin under different water storage periods.

The conventional method is the most applicable method for curing acrylic resin due to its simplicity and relatively good accuracy. Therefore, in various studies this method has been considered the gold standard for comparison with other techniques. Among denture processing methods, injection molding has always been interesting for researchers because of compensation of polymerization shrinkage due to the pressure exerted by injection of the acrylic resin [10].

Table 1. Means and standard deviations of dimensional changes of acrylic specimens

Molding technique	24 hours		48 hours		12 days		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**P**
Conventional-molding	0.114	0.07	0.099	0.06	0.066	0.07	0.000
Injection-molding	0.463	0.03	0.056	0.03	0.001	0.03	0.001
P value	0.002		0.022		0.002		

In this study, SR-Ivocap system (Ivoclar AG, Schaan, Liechtenstein) was used for making injectable acrylic dentures because due to the use of polymethyl methacrylate (PMMA) resin in this technique, the dentures produced with this method can be relined, and there is lower innate processing shrinkage [7].

Different methods such as the use of Vernier calipers, gauges, comparators, micrometers, and radiography have been introduced in different studies to determine dimensional accuracy of denture bases. Garfunkel [11] used a digital caliper to measure changes in VD of occlusion and processed dentures. Lee [12] scanned dentures placed on the respective master casts by computerized tomography (CT) to determine the overall gap formation and dimensional changes of denture bases. Keenan [13] compared the dimensional changes of simulated maxillary complete dentures during polymerization by the use of an internal micrometer. Many studies have evaluated dimensional changes of denture bases by production of different specimens with various shapes. Wolfaardt reported that many different factors affected dimensional changes of acrylic resin dentures [14]. Factors such as size and shape [15], denture thickness [16], different types of denture base materials [17], and presence of teeth [18] can influence dimensional changes during denture processing. Therefore, it is better to use specimens with simple shapes for comparison of dimensional accuracy instead of dentures and denture-shaped specimens. In the present study, rectangular specimens were examined and thus, variables such as shape, size, and thickness of the samples were controlled. By this approach, the physical properties were directly related to acrylic resin itself. Similar to the present study, Salim [19] and Baydas [9] used rectangular acrylic resin plates for dimensional change evaluation. In contrast, complete denture bases were utilized in separate research studies by Jackson [8], Nogueira [20], Abby [21] and Venus [22].

The measurement of dimensional changes in rectangular acrylic plates is difficult. Therefore, the square root of the sum of squares of individual dimensions was used in the present study. For this reason, four reference points (A, B, C, and D) were defined in each acrylic specimen and six dimensional measurements (AB, BC, CD, AD, AC, and BD) were recorded and analyzed. This method is a suitable technique to compare dimensional changes in rectangular specimens [20]. This method was used by Salim [19] and Baydas [9] in different studies to examine dimensional accuracy of processing techniques in rectangular acrylic specimens. In most studies, only the molding technique has been considered as a variable that affects the physical and mechanical properties of dentures while less attention has been focused on the effect of different types of acrylic resins used for molding.

Differences in acrylic resin brands may be considered another variable in addition to molding technique, affecting the mechanical properties. In such studies, in addition to the method of molding, the type of the resin was also different in each group [13, 23-25]. Therefore, the results could not merely be attributed to the type of the molding process itself. As a result, in the present study, denture base resins with the same composition were used (produced by Ivoclar Vivadent/Liechtenstein), which were processed by two different techniques. Therefore, comparisons were made only between the molding techniques and the effect of material type was eliminated. In this study, the dimensional accuracy was compared at 24-hour, 48-hour and 12-day intervals. At each interval, the acrylic plates produced by the injection-molding system were more accurate dimensionally than the samples produced by the conventional curing method. The results revealed the effect of molding methods on dimensional accuracy of specimens. A study performed by Goodkind [26] showed that immersion in water had no significant effect on denture base dimensions.

Consani [23] reported that 90 days of storage of denture bases in water did not result in significant changes in distances between the teeth in comparison to deflasking period. Miessi [27] reported that 180 days of immersion in water caused major dimensional changes and adaptation problems in denture bases. Some authors have reported that water storage of acrylic denture bases results in expansion due to water sorption. Water sorption forces the macromolecules apart and results in acrylic expansion [28]. This expansion compensates the polymerization shrinkage of acrylic resin and improves the adaptation of denture bases with underlying tissues [27]. The present study also confirmed this finding and showed that in both experimental groups, 12 days of storage in water resulted in a significant decrease in dimensional changes and compensated the polymerization shrinkage. As mentioned before, the results of the present study revealed that molding technique affected the dimensional accuracy of test specimens and injection-molding technique showed less dimensional changes compared to conventional processing with press-pack procedure at each time interval (24 hours, 48 hours, and 12 days). This finding was consistent with the results of studies showing that the SR-Ivocap injection system had less innate shrinkage than other molding methods [13, 14, 29].

All aforementioned studies were performed on the denture bases in presence of teeth. Our study was done just on Ivoclar rectangular acrylic specimens in both conventional and injection methods; whereas other studies were performed on complete denture base samples with the presence of teeth, or surveyed on investing materials. Therefore, variables such as shape, size, and thickness of the samples that were not mentioned in other studies, were controlled in ours. By this approach, the dimensional properties were directly related to acrylic resin itself.

Venus [22] showed that the processing technique, rather than the choice of the resins, seems to be the dominant variable with respect to dimensional changes. Sykora [30] reported that higher dimensional accuracy of the injection-molding technique, in comparison to the conventional method, may be related to smaller resin particles compared to the conventional acrylic resin, lower polymerization temperature, absence of resin film formation between the two halves of the flask, and absence of displacement of the two halves of the flask during resin packing.

Thus, according to the results of the previous and present studies, it would seem that the injection-molding method has the advantage of dimensional accuracy over the conventional molding technique.

CONCLUSION

Within the limitation of this study, dimensional changes of acrylic resin specimens were influenced by the molding technique. SR-Ivocap injection procedure had higher dimensional accuracy compared to conventional molding.

ACKNOWLEDGEMENT

The authors would like to thank the Vice Chancellor of Research of Mashhad University of Medical Science for financial support. The results presented in this study have been taken from a postgraduated tesis (no:473) in Mashhad University of Medical Science (MUMS).

REFERENCES

1- Takamata T, Setcos JC. Resin denture bases: review of accuracy and methods of polymerization. Int J Prosthodont 1989; 2: 555-62.

2- Zarb GA, Bolender CL, Carlsson GE. Boucher's prosthodontic treatment for edentulous patients. 11th ed. St Louis: Mosby; 1997. p. 337-42.

3- Jackson AD, Lang BR, Wang RF. The influence of teeth on denture base processing accuracy. Int J Prosthodont 1993; 6: 333-40.
4- Pryor WJ. Injection molding of plastics for dentures. J Am Dent Assoc 1942; 29: 1400-8.
5- Grunewald AH, Paffenbarger GC, Dickson G. The effect of molding processes on some properties of denture resins. J Am Dent Assoc 1952; 44:269-84.
6- Trage R. Experience gained with the SR-lvocap system. Quintessence Int 1980:11:1-6.
7- Schmidt KH. The SR-lvocap system and the structure of denture bases. Quintessenz 1975; 26:59-62.
8- Jackson AD, Grisius RJ, Fenster RK, Lang BR. Dimensional accuracy of two denture base processing methods. Int J Prosthodont 1989; 2:421-8.
9-Baydas S, Bayindir F, Akyil MS. Effect of processing variables (different compression packing processes and investment material types) and time on the dimensional accuracy of polymethyl methacrylate denture bases. Dent Mater J 2003; 22: 206-13.
10- Yunus N, Rashid AA, Azmi LL, Abu-Hassan MI. Some flexural properties of a nylon denture base polymer. J Oral Rehabil 2005; 32: 65-71.
11- Garfunkel E. Evaluation of dimensional changes in complete dentures processed by injection-pressing and the pack-and-press technique. J Prosthet Dent 1983; 50:757-61.
12- Lee CJ, Bok SB, Bae JY, Lee HH. Comparative adaptation accuracy of acrylic denture bases evaluated by two different methods. Dent Mater J2010; 29:411-7. Epub 2010 Jul 28.
13- Keenan PL, Radford DR, Clark RK. Dimensional change in complete dentures fabricated by injection molding and microwave processing. J Prosthet Dent 2003 Jan; 89(1):37-44.
14- Wolfaardt J, Cleaton-Jones P, Fatti P. The influence of processing variables on dimensional changes of heat-cured poly (methyl methacrylate). J Prosthet Dent 1986; 55:518-25.
15- Barco MT Jr, Moore BK, Swartz ML, Boone ME, Dykema RW, Phillips RW. The effect of relining on the accuracy and stability of maxillary complete dentures—an in vitro and in vivo study. J Prosthet Dent 1979; 42:17-22.
16- Woelfel IB, Paffenbarger GC, Sweeney WT, Dimensional changes occurring in dentures during processing. J Am Dent Assoc 1960; 61:413-30.
17- Woelfel J8, Paffenbjrger GC, Sweeney WT. Clinical evaluation of complete dentures made of eleven different types of denture base materials. J Am Dent Assoc 1965; 70:1l70-88.
18- DaBreo EL, Herman P.A new method of measuring dimensional change. J Prosthet Dent 1991; 65: 718-22.
19- Salim S, Sadamori S, Hamada T. The dimensional accuracy of rectangular acrylic resin specimens cured by three denture base processing methods. J Prosthet Dent 1992: 67: 879-81.
20- Nogueira SS, Ogle RE, Davis EL. Comparison of accuracy between compression- and injection-molded complete dentures. J Prosthet Dent 1999; 82: 291-300.
21- Abby A, Kumar R, Shibu J, Chakravarthy R. Comparison of the linear dimensional accuracy of denture bases cured the by conventional method and by the new press technique. Indian J Dent Res 2011; 22: 200-4.
22- Venus H, Boening K, Peroz I. The effect of processing methods and acrylic resins on the accuracy of maxillary dentures and toothless denture bases: an in vitro study. Quintessence Int 2011; 42: 669-77.
23- Consani RL, Domitti SS, Rizzatti Barbosa CM, Consani S. Effect of commercial acrylic resins on dimensional accuracy of the maxillary denture base. Braz Dent J 2002; 13:57-60.
24- Nogueira SS, Ogle RE, Davis EL. Comparison of accuracy between compression and injection molded complete dentures. J Prosthet Dent 1999; 82: 291-303.
25- Alkhatib MB, Goodacre CJ, Swartz ML,

Munoz-Viveros CA, Andres CJ. Comparison of microwave-polymerized denture base resins. Int J Prosthodont 1990; 3: 249-55.
26- Goodkind RJ, Schulte RC. Dimensional accuracy of pour acrylic resin and conventional processing of cold-curing acrylic resin bases. J Prosthet Dent 1970; 24: 662-8.
27- Miessi AC, Goiato MC, Santos DM, Dekon SF, Okida RC. Influence of storage period and effect of different brands of acrylic resin on the dimensional accuracy of the maxillary denture base. Braz Dent J 2008; 19: 204-8.
28- Duymus ZY, Yanikoglu ND. The investigation of solubility values, water sorption and bond strength of auto-polymerising and heat polymerising acrylic resin materials. Eur J Prosthodont Restor Dent 2006; 14: 116-20.
29- Parvizi A, Lindquist T, Schneider R, Williamson D, Boyer D, Dawson DV. Comparison of the dimensional accuracy of injection-molded denture base materials to that of conventional pressure-pack acrylic resin. J Prosthodont 2004; 13: 83-9.
30- Sykora O, Sutow EJ. Comparison of the dimensional stability of two waxes and two acrylic resin processing techniques in the production of complete dentures. J Oral Rehabil 1990; 17: 219-27.