Original Article

A Comparative Study on the Dimensional Change and Flexural Strength of Two Commercially Available Denture Base Materials Processed Using Compression Molding Technique – An *In Vitro* Study

Lagisetty Saiteja, Anam Chandrasekar, G V K Mohan Reddy, N. Sandeep, Ashwini Thandu, Kunchala Sailasri*

Department of Prosthodontics and Crown and Bridge, SVS Institute of Dental Sciences, Mahabubnagar, Telangana, India.

Abstract

Aim: Two commercially available denture base materials were subjected to compression molding to evaluate their dimensional change and flexural strength. **Materials and Methods:** Using Triplex, Triplex reinforced with metal mesh, and Pyrax, a total of 33 denture bases were created. For Triplex, Triplex reinforced with metal mesh, and Pyrax, 33 bar specimens were manufactured and divided into three groups of 11, each. In a thermocycler, 2500 cycles of heat changes are applied to all specimens kept in artificial saliva. The dimensional change was measured using digital caliper and flexural strength is measured by subjecting the specimens to three point bend test. **Results:** The collected data were analyzed using SPSS version 23.0. One-way ANOVA test was applied for three group comparisons (between group) and *post hoc* Tukey test for pairwise comparisons. **Conclusion:** The dimensional change in acrylic resin materials was significantly affected by thermocycling. Denture base resin that is reinforced with a metal mesh greatly improves its flexural strength. Triplex with mesh showed the lowest dimensional change followed by pyrax and the Triplex.

Keywords: Artificial saliva, Digital caliper, Dimensional change, Flexural strength, Thermocycler, Universal testing machine.

Introduction

Since acrylic resins were first used in dentistry in 1937, no other material has been able to replicate the soft tissues of the mouth with the same degree of realism. Poly Methyl Methacrylate (PMMA) is used to create the bulk of denture bases, thanks to the introduction of acrylic resin polymers as denture base materials (PMMA). Compared to existing plastic denture base materials, these materials exhibit ideal physical qualities and great esthetics with a comparatively low toxicity.[1]

For a denture to be a success, it must look good, restore function, and be biocompatible with the surrounding tissues. For optimal chewing efficiency, patient comfort, and oral tissue protection, a denture must be dimensionally stable. Dentures are traditionally made using compression molding and heat activation in a hot water bath for the polymerization of acrylic resin. Resin polymerization causes denture base shrinkage, which is widely known. A denture's fit may be compromised due to issues linked to compression molding. Denture bases now have improved physicochemical characteristics because to changes in the composition and production processes of acrylic resins.[2,3]

Although acrylic resin full dentures are an effective treatment option for the edentulous, they are prone to fracture. An area of the denture base where fracture is most likely to occur is in the midline. Inherent stress on the denture base over time, poor fit of the denture base, poor balance occlusion, denture design and manufacturing problems, low strength of the repair material, ejecting the denture from the mouth while coughing or simply dropping it, excessive bite force, an incorrect occlusal plane, and a high frenal attachment are common causes of these fractures.[5,6]

Access this article online

Website:
www.jrad.co.in

DOI:
https://doi.org/10.53064/jrad.2022.13.4.208

Address for correspondence: Kunchala Sailasri, Department of Prosthodontics and Crown and Bridge, SVS Institute of Dental Sciences, Mahabubnagar, Telangana, India.
E-mail: tejasrockzz02@gmail.com

Received: Mar. 22, 2022; **Accepted:** Apr. 16, 2022; **Published:** May. 24, 2022

How to cite this article: Saiteja L, Chandrasekar A, Reddy GV, Sandeep N, Thandu A, Sailasri K. A Comparative Study on the Dimensional Change and Flexural Strength of Two Commercially Available Denture Base Materials Processed Using Compression Molding Technique – An *In Vitro* Study. J Res Adv Dent 2022;13(4):90-95.

Denture repair is a viable option for individuals who cannot afford or have insufficient time to wait for a new denture to be made.[7]

Metal mesh denture strengthening is a viable option for preventing fractures. It is not unusual to have a buccolingual breadth of 5 mm or less in cases of significant resorption of the remaining ridge. As a result, the anterior section of the denture is more prone to fracture. As a result, utilizing metal mesh or other denture reinforcing materials is a cost-effective but time-consuming process for reinforcing dentures.

Aim of the study

The purpose of this study, compression molding technique, was used to examine the dimensional change and flexural strength of two commercially available denture base materials.

Materials and Methods

Methodology for dimensional change

A maxillary edentulous cast was taken and a Type I Modeling wax sheet (Hindustan Dental Pvt Ltd, Hyderabad) of 2 mm thickness is adapted over the edentulous maxillary cast to maintain uniform thickness of denture bases (Figure 1). Denture bases were created utilizing a compression molding process in an acrylizer machine at 75°C for 90 min, followed by 30 min at 100°C.

When the flasks had cooled down for 24 h, the samples were removed and polished. Similarly, all 33 samples were made using Triplex (Ivoclar, Vivadent Inc), Triplex reinforced with metal mesh (Comdent Corporation, Mumbai), and pyrax (Pyrax polymars, Roorkhee, Uttarakhand) heat cure acrylic resins for all three groups (Figures 2-4). For Triplex reinforced with metal mesh group, the mesh is adapted over the edentulous cast after dewaxing (Figures 4 and 5).

Measurement of the reference points

It was determined by measuring the AC and BD dimensions on the stone castings and the intaglio surface of acrylic resin bases following processing cycles using digital caliper (Flower High Precision, Newton, Massachusetts, USA) with a 10 nm precision. All the specimens are stored in artificial saliva and subjected to thermal changes from 5° to 45° up to 2500 cycles using a thermocycler (Khushboo Scientific Private Ltd, Nariman, Mumbai).

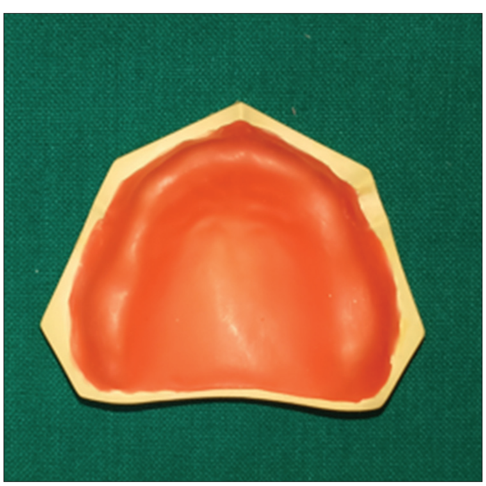


Figure 1: Modeling wax adapted to dental cast

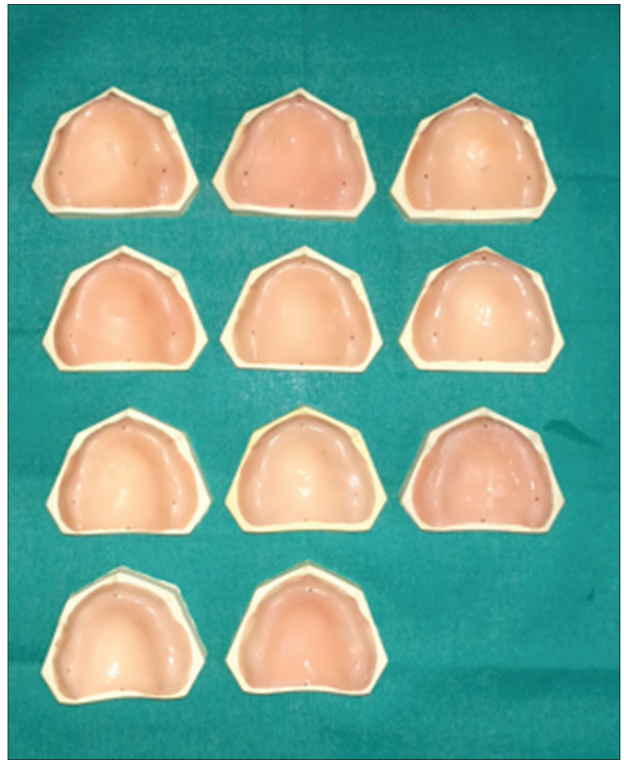


Figure 2: Pyrax Denture bases

Figure 3: Triplex denture bases

Methodology for flexural strength

Mold space preparation

Pyrax Hi Impact heat cure acrylic resin was used to heat cure 33 samples, which were divided into three groups of 11 each. Three milled wax bars (Ceramill Mall, Amann Girrbach, Koblach, Austria) sample analog with 65 mm × 10 mm × 3 mm dimensions were prepared as per ISO norms. A putty index was made of the specimens and a flat layer of putty was placed over the putty indices.

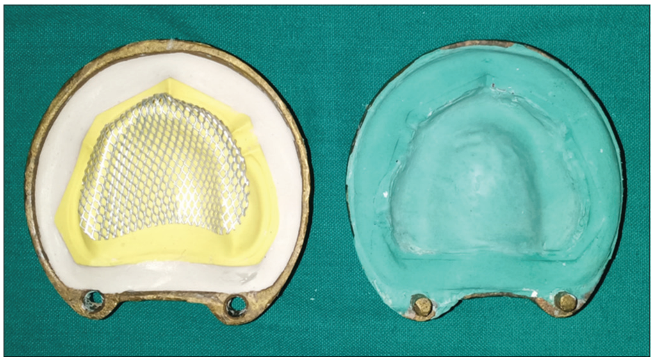


Figure 4: Stainless steel mesh adapted to the cast after dewaxing

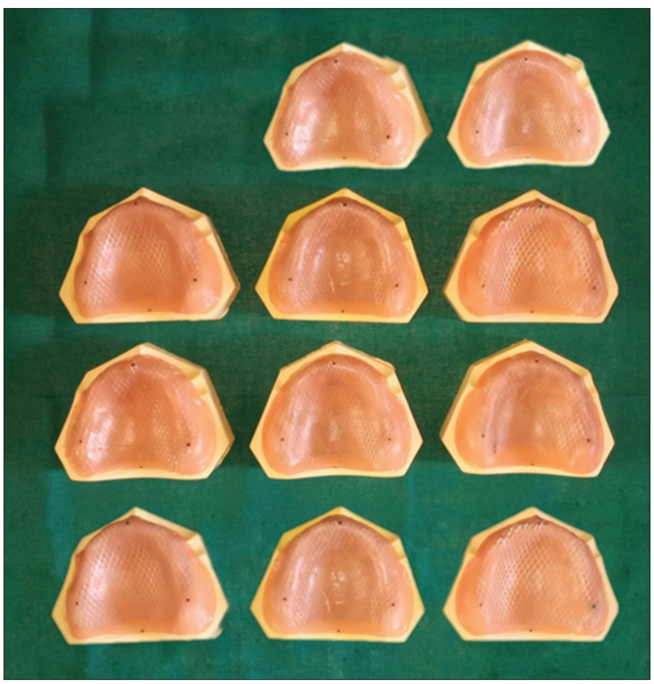


Figure 5: Triplex Denture bases reinforced with metal mesh

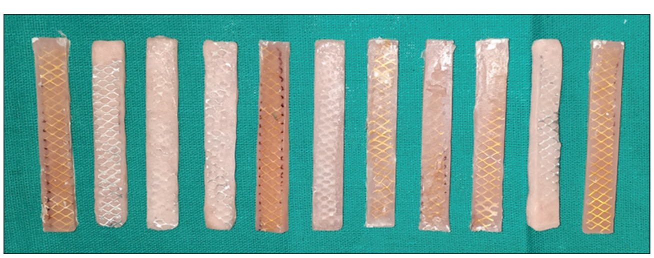


Figure 6: Bar specimens made with Triplex reinforced with metal mesh

Fabrication of group A, B, and C specimens (triplex, triplex reinforced with metal mesh, and pyrax hi impact heat cure acrylic resin)

PMMA is the primary component of the substance (Triplex and Pyrax Hi Impact heat cure acrylic resin), which is offered in powder and liquid form. In accordance with the manufacturer's instructions, the material was manipulated. Standard polymer/monomer ratio is 1.00 g/0.5 ml. Required amount of monomer was dispensed into the mixing jar, and slowly the corresponding quantity of polymer was added. Spatulation was used to wet the polymer particles equally for around 20–30 s. Hydraulic press was used to push this material into the lubricated mold cavity and the flask chambers were approximated under the 2000 psi pressure. Later, the flask was fixed to a clamp and placed in an acrylizer unit. For 90 min, they are exposed to a temperature of 75°C, followed by 30 min of exposure to a temperature of 100°C. When the flasks had cooled down for 24 h, the samples were removed and polished. All the 22 examples were made using Triplex and Pyrax, as well (Figures 7 and 8). Before packing the Triplex reinforced with metal mesh group, the mesh is put on the mold area. All 11 samples were processed in the same manner (Figure 6). An Universal Testing Machine (Germany's Zwich/Roell Z020) measures flexural strength. All the specimens are stored in artificial saliva and subjected to thermal changes from 5° to 45° for 6 months using a thermocycler (Khushboo Scientific Private Ltd, Nariman, Mumbai). All the data measured for dimensional change and flexural strength was collected and subjected to statistical analysis.

Results

The collected data were analyzed using SPSS version 23.0. One-way ANOVA test was applied for three group comparisons

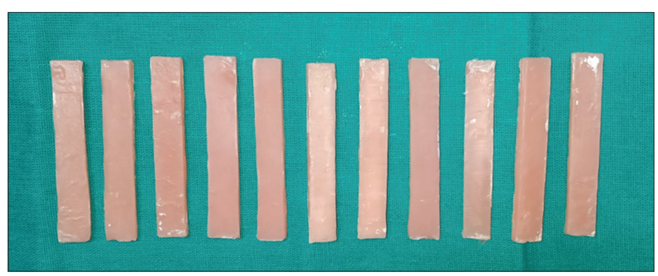


Figure 7: Bar specimens made with Triplex

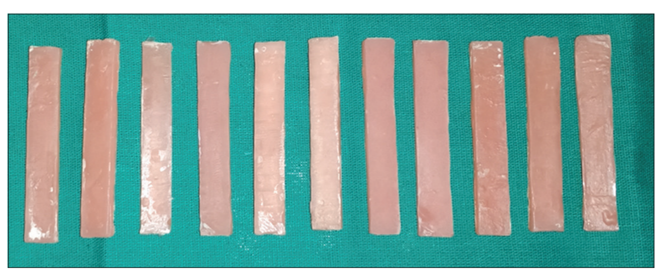


Figure 8: Bar specimens made with Pyrax

(between group). It was deemed statistically significant when $P < 0.05$.

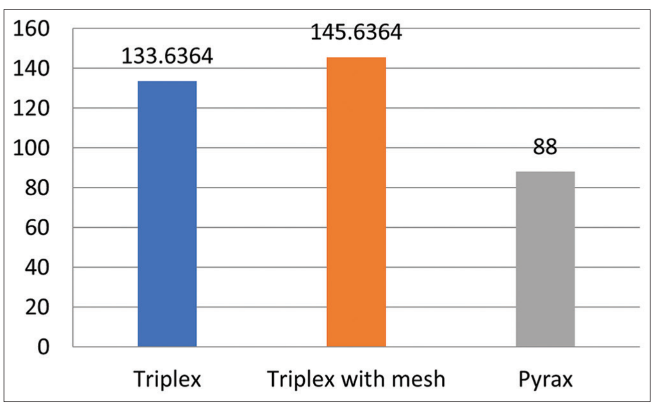
The mean flexural strength value of Triplex is 133.63 ± 8.93, Triplex with mesh is 145.63 ± 11.53, and Pyrax is 88 ± 6.87. One-way ANOVA test detected highly significant difference (P – 0.000) between them, in which the mean of Triplex with mesh is highest and Pyrax is lowest (Table 1 and Graph 1).

Table 2 and Graph 2 show the mean differences in dimensional change between the reference points (A-B, B-C, C-D, and D-A) in the Triplex group before and after thermocycling. The mean difference in dimensional changes before and after thermocycling for A to B is 0.29. The mean difference in dimensional changes before and after thermocycling for B to C is −0.018. The mean difference in dimensional changes before and after thermocycling for C to D is 0.12.The mean difference in dimensional changes before and after thermocycling for D to A is 0.20 and paired samples t-test detected no significant difference between all pairs.

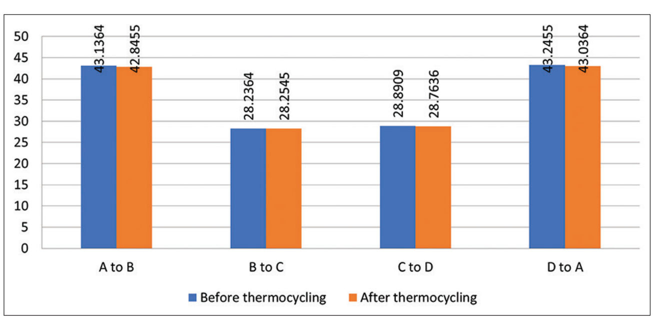
Table 1: Flexural strength between three sub groups

	N	Mean	Std. Deviation	F value	Sig.
Triplex	11	133.6364	8.93614	117.32	0.000 HS
Triplex with mesh	11	145.6364	11.53493		
Pyrax	11	88.0000	6.87023		

Statistical test applied: One-way ANOVA; HS: Highly significant at P<0.01



Graph 1: Comparison of mean flexural strength between three subgroups



Graph 2: Mean dimensional change in Triplex before and after thermocycling

Discussion

To make denture bases, prosthetic dentists use PMMA resin, which has excellent processing and friendly features. Due to the ease of production, economy, light weight, less absorption of water, repairability, and esthetics of PMMA denture base material, it has grown in popularity. Its low impact strength and fatigue resistance are only two of its disadvantages. In spite of this, the fracture strength of PMMA is not deemed to be sufficient, and this is shown in the number of denture repairs that are made each year.[6]

Anteroposterior distance changes were less than mediolateral distance changes[4]. The posterior portion of the maxillary dentures exhibits the greatest dimensional change, as is well-known.[8-10] Denture base dimensional accuracy has been studied using a variety of techniques, including Vernier calipers, gauges, comparators, millimeter, and radiography. A digital caliper was utilized by Anderson GC[12] to measure the vertical dimension of occlusion in dentures that had been produced. An internal micrometer was used by Komiyama et al [3] to compare the dimensions changes of simulated maxillary full dentures during polymerization. In this investigation, specimens were maintained in artificial saliva for a few days and then treated to 2500 cycles of thermocycling to imitate a portion of the oral environment[15]. A digital calipers is used to measure the resulting dimensional change.

Maxillary denture fractures occur twice as common as mandibular denture fractures. Poor fit and lack of occlusion are the most prevalent causes of denture breakage.[13] About 80% of the mandibular dentures break owing to impact failure, whereas maxillary dentures break due to fatigue.[2]

Several methods are used to examine the stress distribution within the dentures. A tensile tension at the labial aspect and a lingual stress on the polished surfaces of the incisors on the maxillary dentures' polished surfaces has been postulated. A weak spot in the upper denture's midline can occur due to excessive stress placed on the incisive papilla on the tongue's side of the teeth. This can lead to midline fractures, which can lead to bone loss.[3,13]

Compression, tension, and shear strengths are all used to characterize a material's flexibility. The greater the material's tensile and compressive strengths, the greater the force required to shatter it[17]. This test is used to determine the flexural strength of a material since it mimics the stress that would be placed on a denture during chewing. One approach of reducing midline stress is to reinforce the denture base material. The second method is to reduce midline tension. Denture designs that increase the thickness of the denture base or alter the placement of the teeth can help alleviate midline tension. However, the denture base's thickness might diminish tongue space, which inhibits the ability to communicate. It is possible to fortify the denture base in two ways: either by reinforcing the complete denture base or just the vulnerable portions.[16]

PMMA's mechanical strength has previously been studied in relation to various metal reinforcements.[9,18] To test this,

Table 2: Mean dimensional change in Triplex (before and after thermocycling)

	Mean	Std. Deviation	Mean Difference	*t* value	*P* value
Pair 1					
A to B (Before thermocycling)	43.1364	0.50452	0.29091	0.993	0.344
A to B (After thermocycling)	42.8455	0.73262			
Pair 2					
B to C (Before thermocycling)	28.2364	0.69609	−0.01818	-0.072	0.944
B to C (After thermocycling)	28.2545	0.68464			
Pair 3					
C to D (Before thermocycling)	28.8909	0.73953	0.12727	0.443	0.667
C to D (After thermocycling)	28.7636	0.59879			
Pair 4					
D to A (Before thermocycling)	43.2455	0.96370	0.20909	0.623	0.548
D to A (After thermocycling)	43.0364	0.73386			

Statistical test applied: Paired samples *t*-test

Vallittu and Lassila used sandblasting on the thick wire and found that it improved the resin's ability to withstand fractures. A metal mesh added to PMMA, according to Polyzois, would boost the material's fracture strength.[19] Metal wire in poly methyl methacrylate considerably increased its flexural strength, according to Lee *et al*.[22] in another study.

A Universal Testing Machine was then used to load each sample. Flexural tests are essentially a three-point flexure test on a bar supported at both ends. At the site of application of the load, these tests measure stresses as compressive and tensile/shear at the point of resistance to the given load, which is analogous to the stresses created during functional motions. The flexural strength of denture base resins may also be determined using a three-point bend test,[14] according to several research.

In the present study, 33 samples were used to measure flexural strength. Wax bars were milled of dimensional 65 mm × 10 mm × 3 mm and were invested in denture flasks. Later, the specimens were subjected to thermocycling and were subjected to 3 point bend test. According to the results of this study, Triplex reinforced with metal mesh has the higher values of flexural strength than the Triplex and Pyrax.

The flexural strength of a heat-cured PMMA acrylic resin was investigated by Aydin C,[17] who used high-performance polymer (BioHPP) and metal mesh reinforcement. It was found that the flexural strength of PMMA was greatly improved when supplemented with metal mesh, but that BioHPP had no influence on PMMA's flexural strength. This research's findings were in line with those of the present study.

The limitations of the present study are as follows:

1. The study's experimental design had limitations when it came to effectively mimicking clinical situations, considering its aim to imitate in vivo conditions.
2. Over time, reinforcing elements are likely to weaken the mechanical qualities of the acrylic resins, resulting in a decrease in denture longevity.
3. Bar specimens used in the study have flat surfaces, whereas clinically, the denture bases have convex and concave surfaces.

Conclusion

Within the limitation of this study, the following conclusions can be drawn:

- Dimensional changes of acrylic resin specimens were influenced by the molding technique. Triplex with mesh showed the lowest dimensional change followed by Pyrax and the Triplex.
- Heat polymerized denture base resin's flexural strength is significantly improved using metal mesh to strengthen PMMA, according to the results of this study.
- Triplex reinforced with mesh had the highest flexural strength of the materials tested, followed by Triplex and lastly Pyrax.
- Thermocycling had a substantial influence on the dimensional change of the acrylic resin materials.

References

1. Skinner EW. Acrylic denture base materials: Their physical properties and manipulation. J Prosthet Dent 1951;1:161-7.
2. Meng TR, Latta MA. Physical properties of four acrylic denture base resins. J Contemp Dent Pract 2005;6:93-100.
3. Komiyama O, Kawara M. Stress relaxation of heat-activated acrylic denture base resin in the mold after processing. J Prosthet Dent 1998;79:175-84.
4. Mowery WE, Burns CL, Dickson G, Sweeney WT. Dimensional stability of denture base resins. J Am Dent Assoc 1958;57:345-53.
5. Darbar UR, Huggett R, Harisson AA. Denture fracture a survey. Br Dent J 1994;176:342-5.
6. Gruszer M, Kovacs G. Az akrilat lemezes potlasok toresvonalainak vizsgalata Study of the fracture line of acrylate prosthetic plates. Fogorv Sz 1970;63:303-6.
7. Lord JL, Langdon BA. Simplified repairs and alterations of removable partial dentures and conversion of an existing removable partial denture to an immediate denture. Dent Clin North Am 1970;14:615-30.
8. Barbosa DB, de Souza RF, Pero AC, Marra J, Compagnoni MA. Flexural strength of acrylic resins polymerized by different cycles. J Appl Oral Sci 2007;15:424-8.
9. Gharechahi J, Asadzadeh N, Shahabian F, Gharechahi M. Dimensional changes of acrylic resin denture bases: Conventional versus injection-molding technique. J Dent (Tehran) 2014;11:398-405.

10. Savabi G, Savabi O, Dastgheib B, Nejatidanesh F. Effect of the processing cycle on dimensional changes of heat-polymerized denture base resins. Dent Res J (Isfahan) 2015;12:301-6.
11. Chitchumnong P, Brooks SC, Stafford GD. Comparison of three and four-point flexural strength testing of denture-base polymers. Dent Mater 1989;5:2-5.
12. Anderson GC, Schulte JK, Arnold TG. Dimensional stability of injection and conventional processing of denture base acrylic resin. J Prosthet Dent 1988;60:394-8.
13. 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.
14. Ayaz EA, Bagış B, Turgut S. Effects of thermal cycling on surface roughness, hardness and flexural strength of polymethylmethacrylate and polyamide denture base resins. J Appl Biomater Funct Mater 2015;13:e280-6.
15. de Souza Silva C, Machado AL, de Andrade Lima Chaves C, Pavarina AC, Vergani CE. Effect of thermal cycling on denture base and autopolymerizing reline resins. J Appl Oral Sci 2013;21:219-24.
16. Nogueira SS, Ogle RE, Davis EL. Comparison of accuracy between compression-and injection-molded complete dentures. J Prosthet Dent 1999;82:291-300.
17. Aydin C, Yilmaz H, Caglar A. Effect of glass fiber reinforcement on the flexural strength of different denture base resins. Quintessence Int 2002;33:457-463.
18. 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.
19. Urban VM, Machado AL, Vergani CE, Giampaolo ET, Pavarina AC, de Almeida FG, *et al*. Effect of water-bath post-polymerization on the mechanical properties, degree of conversion, and leaching of residual compounds of hard chairside reline resins. Dent Mater 2009;25:662-71.
20. Kim MJ, Kim CW. A comparative study on the dimensional change of the different denture bases. J Korean Acad Prosthodont 2006;44:712-21.
21. Saini R, Kotian R, Madhyastha P, Srikant N. Comparative study of sorption and solubility of heat-cure and self-cure acrylic resins in different solutions. Indian J Dent Res 2016;27:288-94.
22. Lee CJ, Bok SB, Bae JY, Lee HH. Comparative adaptation accuracy of acrylic denture bases evaluated by two different methods. Dent Mater J. 2010;29:411-7.