

Comparative study of flexural strength of four acrylic resins before and after thermocycling process

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Objectives Acrylic resins are one of the most important denture base materials in dentistry due to their favourable mechanical and physical properties. The purpose of present study is to compare 4 available acrylic flexural strength properties before and after thermocycling.

Methods Acrylic resin specimens of Meliodent (Heraeus Kulzer, Hanau, Germany), Vertex (Vertex-dental BV, Zeist, Netherlands), Mead way (Dental Supplies LTD, Surrey, England) and Versacryl (Keystone, Gibbstown, NJ) prepared according to ISO 20745-2 (in dimensions of 25x7x2 mm). Total of 40 blocks obtained: 10 specimens from each type of acrylic resin made one group. Each group divided into two equal subgroups. Flexural strength of specimens in subgroup 1 measured before thermocycling process whereas same measurement carried out for subgroup 2 after thermocycling (5000 cycles) process. Three-point bending test used for the final measurement. Data were analyzed using two-way ANOVA and Bonferroni post-hoc tests with mean difference significant at the 0.05 level ($P < 0.05$)

Results Mead way acrylic resin showed a higher level of flexural strength (105.98 ± 4.90 MPa) without thermocycling compared to Meliodent and Vertex resins, however, no significant difference was observed between Mead way and Versacryl resin's same property. Data analysis revealed that thermocycled Meadway resin had highest flexural strength (90.25 ± 56.30 MPa) in comparison to other resins (Meliodent, Vertex and Versacryl). Flexural strength appeared significant reduction in all resins after polymerization.

Conclusion Mead way resin presented the highest flexural strength in both thermocycled and non-thermocycled resin groups. Nonetheless, thermocycling process resulted in notably lower measurements of flexural strength in Versacryl, Vertex, Meliodent and Mead way resins.

Keywords Flexural strength, Acrylic resin, Polymerization

Introduction

One of the most significant factors affecting an acrylic denture's long-term success in the treatment of edentulous patients is the physical property of the denture base material¹. Acrylic-based resins are the most commonly used denture base materials². They are not only biocompatible with the intraoral environment, but also, they present favorable rigidity³.

Heat-cured poly Methyl Methacrylate resins are used as denture base material due to their characteristics, satisfactory aesthetics, low water solubility and absorption, no toxicity, reparability and ease of use for denture fabrication. Compression molding is a popular method of resin curing for denture construction⁴⁻⁶.

There are numerous physical and mechanical properties of acrylic resin materials that are affecting the quality of a denture, namely; flexural strength, dimensional stability, shear strength, impact strength, rigidity (modulus of elasticity), water solubility and water absorbability⁷.

Flexural strength is an important element in the quality of a denture. Flexural strength is a physical property that determines a materials fracture resistance when facing a flexural stress. When a flexural stress implements to a material surface, elastic deformity occurs, followed by

plastic deformation and finally results in fracture⁸.

Although acrylic resins present limitations such as low impact strength, flexural strength and fatigue limit that may results in possible variable denture fractures⁸⁻¹⁰, but remains to be the most commonly used denture fabrication material. Moreover, acrylic resin materials rapid appearance change, loss of physical and mechanical properties in the oral environment due to their water solubility and absorption are additional drawbacks of this material⁸. Denture resins are commonly exposed to thermal stresses in the oral cavity, by hot and cold foods and beverages. This might impact the water absorption. The flexural strength of denture base acrylic can be diminished by the penetrated water molecules between the polymer chains that act as plasticizers within the polymer network resins¹¹. The flexural strength of denture base acrylic resins has been addressed in previous studies^{8, 11, 12}, however, there are limited studies regarding the effect of thermocycling on the flexural strength¹¹.

Denture base fracture is a major problem in denture prosthesis and efforts has been made to tackle this issue. Among most important parameters of a denture base material are its strength and rigidity. Therefore, selecting a proper denture base material is critical and should be carried out sensitively^{1, 7}. This is very important for clinical use, particularly in selecting acrylic resins, to evaluate the

flexural strength considering thermocycling process. The need to improve the strength of the denture base has been highlighted in previous studies^{8,11,12}. Therefore, this in vitro study was designed to compare four commercially available acrylic resins⁷ (Meliodent, Vertex, Mead way and Versacryl) flexural strength before and after thermocycling process.

Methods

In this study, ten specimens fabricated from each of heat cured acrylic resins: Meliodent (Heraeus Kulzer, Hanau, Germany), Vertex (Vertex-dental BV, Zeist, Netherlands), Mead way (Dental Supplies LTD, Surrey, England) and Versacryl (Keystone, Gibbstown, NJ). A special metal mold (25mm×7mm in thickness of 2 mm) was fabricated for forming the wax blocks. The wax patterns for conventional water bath polymerization were invested in the brass flask and were allowed to set. After the dew axing process, acrylic resins were mixed and polymerized according to the manufacturer's instructions. Specimens which showed porosity discarded and replaced with new ones. It made a total of 40 study acrylic resin blocks. (Figure 1).



Figure 1- Prepared acrylic resin blocks

All specimens preserved in distilled water for seven days at room temperature. Subsequently they transferred into an incubator for 24 hours in 37 centigrade degrees.

The prepared specimens from four acrylic resins were allocated to 2 subgroups so that each subgroup will contain 5 blocks of each type of acrylic resin; subgroup 1 specimens were not undergone thermocycling process, subgroup 2 specimens, placed in the thermocycling machine(Dorsa ,Iran) and thermocycled 5000x between 5 and 55 centigrade degrees with dwelling time of 20 seconds. Universal testing machine (Sentam, Tehran, Iran) used to perform three-point bending flexural strength test, under the constant speed of 5 mm/min speed for all specimens (Figure 2). The specimens were deflected until fracture has been occurred.

To measure the flexural strength, specimens placed horizontally over two end point bars of a universal testing machine (samples were not fixed in place), followed by application of load to the top of samples from one single point and placed under strain (Figure 2) which is called three-point bending test (3pb) or flexural test¹³. The flexural strength test is part of ADA 12 (ISO) specification for

denture base resins¹⁰.

The resulted flexural strength (MPa) numerical value was calculated using the equation below⁸:

$$\sigma = \frac{3FL}{2bh^2}$$



Figure 2: Specimen placed on Universal flexural test machine for three-point bending test

Where F is the applied maximum load before fracture to the samples and measured in Newton, L is the distance between two supporting end point bars measured in millimeters, b is the width of the specimen measured in millimeter and h is the thickness of the sample in millimeters. Specimens' width and thickness measured just before placing the study blocks in distilled water.

The software of universal testing machine used for calculation of the results. If the calculated number was less than 65 MPa in 4 or 5 samples, the test accepted as correct. Data analyses carried out using IBM SPSS (SPSS Inc., IBM Corporation, NY, USA) version 20 for windows.

Effects of thermocycling process on all of the acrylic resin samples measured using two-way analysis of variance (ANOVA). Additionally, pairwise comparison of specimen's flexural strength properties before and after thermocycling carried out using Bonferroni test (P value < 0.05).

Results

Flexural strength means and standard deviation of both study groups are listed in Table 1. Two-way ANOVA showed that both type of acrylic resin and thermocycling process, both have a significant effect on resin's flexural strength (p<0.001). In other words, the flexural strength value significantly affected by the group of resins (commercial brand) and thermocycling process. Nevertheless, the interaction between thermocycling and type of resin did not have a significant effect on flexural strength (p=0.07).

The result of pairwise comparisons of acrylic resins in terms of flexural strength without thermocycling by using Bonferroni test showed that the flexural strength of Mead way resin with Meliodent (p=0.003) and Vertex (p=0.0004) have significant differences.

All the resin's flexural strength property after thermocycling process compared in groups of two using

Bonferroni test. The results revealed significant higher values of flexural strength in Mead way compared to

Meliodont ($p=0.004$), Versacrly ($p=0.009$) and Vertex ($p<0.001$).

Table 1- Mean flexural strength (MPa) of 4 acrylic resins before and after polymerization.

Groups	Thermocycling process	Mean	Standard Deviation
Mead way	Before	105.9800	4.90581
	After	90.2560	6.30806
Versacrly	Before	99.2320	6.64556
	After	75.6160	9.06319
Vertex	Before	90.2780	9.49587
	After	69.0980	2.32341
Meliodont	Before	89.9040	2.48875
	After	74.5820	6.38859
Total	Before	96.3485	9.60239
	After	77.3880	9.51797
	Total	86.8682	12.66558

Pairwise comparison of acrylic resin's flexural strength conducted using Bonferoni test before and after thermocycling process. The results revealed significant disparity between flexural strength of Meliodent ($p=0.001$), Mead way ($p<0.001$), Versacrly ($p<0.001$), and vertex ($p<0.001$) both before and after thermocycling process in which before processing they performed significantly higher flexural strength than after thermocycling process.

Discussion

Flexural strength is one of the most important parameters of a denture base material in defining dentures physical strength when facing patient-imposed mastication and high-impact forces. The flexural strength test is part of ADA 12 (ISO) specification for denture base resins¹⁰. Three-point flexural strength test is commonly used to compare denture base materials since it produces the same stress level that is applied to prosthesis during chewing function¹⁴. The purpose of current study was to compare the flexural strength of four different acrylic resin brands (Meliodent, Vertex, Meadway and Versacrly) before and after polymerization process.

According to American Dental Academy (ADA) recommendation, heat cured acrylic resin's flexural strength should be between 78 to 92 MPa¹⁰ which all the resins in this study showed flexural strength in this scale. Numerous factors can affect flexural strength properties, namely; polymerization level, powder particle size, porosity, polymer's molecular weight and excess monomer, fillers and plasticizers¹³. Longer polymerization time reduces porosity and increases polymerization level and flexural strength of the acrylic materials. On the other hand, shorter polymerization cycle causes increased monomer remnants. Plasticizing of excess monomer can have adverse effect on the flexural strength of the acrylic resin materials¹³.

The present study revealed that polymerized Mead way resin exhibited the highest flexural strength before thermocycling process followed by Versacrly, Vertex and Meliodent resins respectively. Twin block comparison of

the acrylic resin's flexural strength without thermocycling process showed significantly higher flexural strength of Mead way resin compared with Meliodent and Vertex. Similarly, Memon et al. (2001)¹⁵ reported that Meliodent resin had the lowest flexural strength compare to Acron MC and Microbase resins. Hemmati et al. (2015)¹⁶ Also showed that the flexural strength in Meliodent acrylic resin was lower than Bre.Crystal acrylic resin.

In the present study, in the thermocycling setting after polymerization process, there was a statistically significant high flexural strength in Mead way resin compared to Versacrly, Vertex and Meliodent resins.

Furthermore, the results of our study showed a significant impact of the type of resin (resin brand) and thermocycling process on flexural strength property. In other words, the amount of measured flexural strength affected by type of resin being studied. Also, the measured numbers showed raised disparity among both conditions of thermocycling and not thermocycling process. Nevertheless, interaction effect of resin type and thermocycling process did not have a significant effect on flexural strength. In line with our results, Machado et al. (2012) compared the effects of two acrylic resins, including Lucitone (heat cure high-impact acrylic resin) and Eclipse (light cure activated polyoretan), and thermocycling process on the flexural strength. Their results showed that both of the properties (type of resin and thermocycling process) had a significant effect on the flexural strength separately. However, interaction between resin type and thermocycling did not have a significant effect on flexural strength¹⁴.

The present research showed a significant discrepancy between mean flexural strength of Meliodent, Mead way, Versacrly and Vertex when studied in pair comparison groups with and without thermocycling process. Additionally, the flexural strength value was significantly higher under thermocycling process. In line with our results, previous studies also showed a significant decrease in flexural strength after thermocycling^{14, 17}. In contrast to our results, a study showed that the flexural strength in acrylic denture base resins did not change after six months'

thermocycling¹⁸. Reduced flexural strength after thermocycling process can be explained by water absorption of resin material which leads to PMMA molecules polarization and subsequently water molecules spread into inter-polymer chain.

Conclusion

Mead way resin have the highest flexural strength in non-

thermocycling conditions compared to Meliodent, and Vertex resins, and even after the thermal cycles, it have the highest flexural strength compared to the four types of acrylic resin. The flexural strengths of all resins were significantly reduced after thermocycling.

Conflict of Interests

None Declared ■

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