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Evaluation of Flexural Strength, Hardness, Adaptation and Dimensional Changes in Three Commonly Available Denture Base Resins - An In Vitro Study

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Abstract

Aim: The purpose of this study was to evaluate and compare the flexural strength, hardness, adaptation, and dimensional changes of the three heat cure denture base resins polymerized by conventional water bath and by microwave energy.

Materials and Methods: Three commonly used heat cure resins were chosen in this study, namely Acralyn-H, DPI, Triplex. These heat cure resins polymerized by conventional water bath and by microwave energy. A total of 18 groups with a total sample size of 180 (60 for flexural strength test and 60 for hardness test, 60 for adaptation and dimensional changes). Flexural strength testings were performed using 3- point bending tests, and results were recorded in MPa. Hardness testings were performed using shore D durometer, and results were recorded in Shore D units. Dimensional changes and adaptation testings were performed using the vedio inspectory system, and results were recorded in mm. The results were then analyzed by using t-test, one way ANOVA and Scheffe's Post Hoc test.

Results: The ANOVA test explains a significant difference of flexural strength and hardness for samples polymerized by conventional water bath and microwave energy. ANOVA test explains no significant difference of adaptation for samples polymerized by conventional water bath and microwave energy. ANOVA test explains significant difference of dimensional changes among resins polymerized by conventional water bath and no significant difference of dimensional changes among resins polymerized by microwave energy.

Conclusion: Within the limitations of the study it was concluded that the resins polymerized by microwave energy showed better flexural strength, hardness,

adaptation and dimensional stability compared with resins polymerized by a conventional water bath. Among the resins, DPI shows better flexural strength, hardness, adaptation and dimensional stability followed by Acralyn-H and Triplex.

Keywords: Flexural strength, Hardness, Dimensional changes, Adaptation, Heat cure, Microwave, Acrylic resins.

Introduction

Denture base resins are most commonly used in fabricating dental prostheses, including complete dentures, removable partial dentures, and implant supported prostheses.[1] Based on the method used for activation 3 types of resins namely self cure, heat cure, and light cure are available. Depending upon heat source many techniques are available for initiating the polymerization of which water bath technique is most commonly used. With advances in polymer science led to development of microwave activation polymerization[1]. The objective of this study is to compare flexural strength, hardness, dimensional changes and adaption among three different resins cured by conventional technique and microwave technique.

Materials and Methods

Three polymethyl methacrylate heat cure resins selected for this study were Acralyn-H(60) (Vizag, Andhrapradesh, India), DPI(60) (Vizag, Andhrapradesh,India), and Triplex (60) (Chennai, Tamil nadu, India). These resins were polymerized by the Conventional water bath technique and microwave curing. In the conventional technique, a water bath with a heating mechanism is used, whereas, in the microwave technique, microwave energy is used.

Fabrication of samples for flexural strength and hardness test

10 samples per each material, and each technique is prepared. A metallic steel die of dimensions 65.2 mm length, 10.7 mm width 2.7 mm thickness were fabricated (Figure 1). A rectangular-shaped plastic case was used as a tray for making an impression. By using polyvinyl siloxane (putty) elastomeric material, the impressions of the die were made. The modeling wax was melted and poured into the mold space.

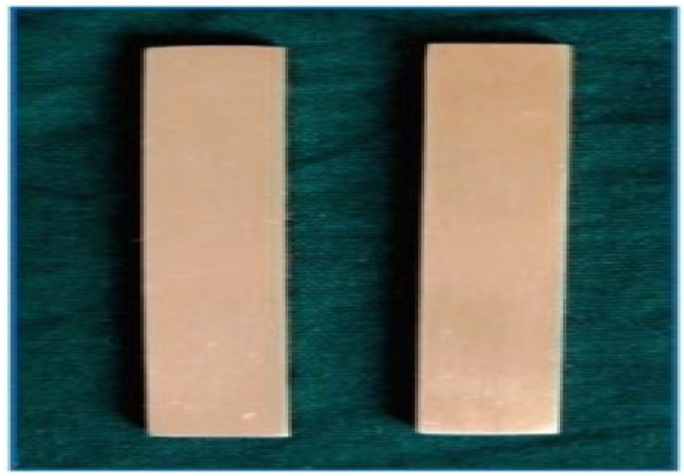

Figure 1: Metal die for flexural strength and hardness

In conventional method dewaxing done at 100°C for 5min. At dough stage, acrylic resin is packed and the pressure of 1200psi is maintained. Bench curing is done for one hour. Trial closure was done by using cellophane sheet, the flask halves were separated and any flash is removed . Bench curing for one hour. Polymerization by immersion in water in Electronic Acrylizer, C-73a, (Confident) with a digital electronic meter for adjusting time and temperature at 65 °C for 90 minutes, followed by 100 °C for 30 minutes is used. The short curing cycle was preferred because the thickness of the specimen is less i.e 2.5 mm, and it takes less time. For thin sections of acrylic resin short curing cycle is preferable, and it will attain a better strength than a similar specimen cured at 71°C

(160°F) for 9 hours with no boiling.[2] Bench cooling was done for one hour.

For microwave curing, special microwaveable flasks made up of glass fiber reinforced polyester resins, which are held together with bolts, were used. The flashing and packing process are the same as that of the conventional technique. Dewaxing done at 500W for one minute is used. Bench curing for one hour. Curing done at 500W for 3min. Bench cooling is done for one hour.

Trimming was done by using rotary burs, and the thickness of the sample was reduced by using special jig (Figure 2), which holds the samples, and around 10 strokes were used in a single direction. 200 and 400 grit waterproof emery paper were used for finishing the samples. Polishing was done by using a rag wheel and pumice. According to ADA specification 12 the dimensions of samples are 65 mm length, 10 mm width, 2.5 mm thickness.

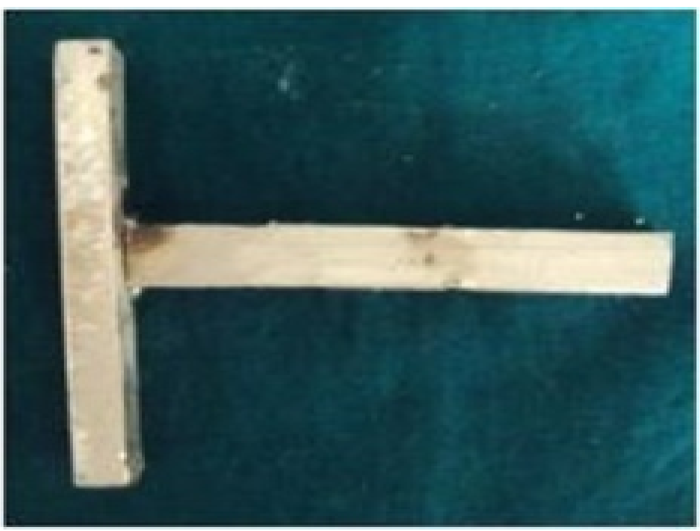

Figure 2: Metal die for adjusting thickness of flexural strength and hardness samples

Fabrication of samples for measuring dimensional changes and adaptation

A metallic steel die of dimensions 40 mm length, 10 mm width and 5 mm thickness from the deepest part was made simulating the cross-section of maxillae(Figure 3). The surface of the die was well rounded, smooth, and evenly polished. By using polyvinyl siloxane in putty form and light body impression of the die was made. Then casts were obtained by dental stone. The 3mm thickness flexible vaccuform sheet is adapted to the casts by using vaccum former. The advantage with vaccuform sheet was its uniform thickness of samples was obtained. These vaccuform sheets were sealed to the casts by flowing a thin layer of molten modeling wax. Dewaxing, followed by polymerization, was done.

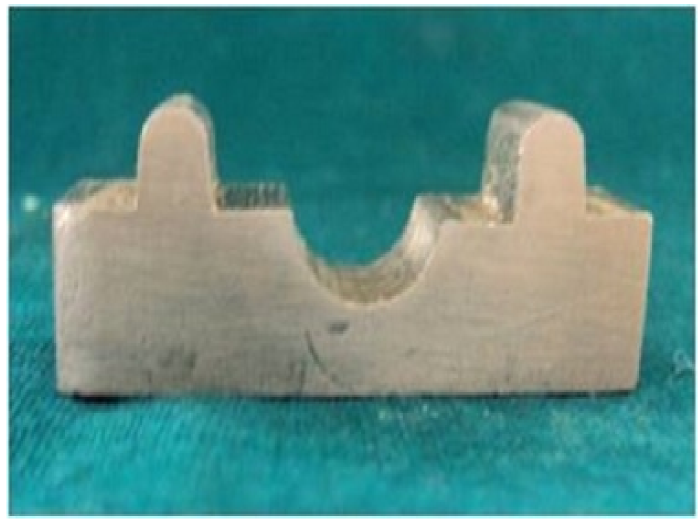

Figure 3: Metal die for adaptation and dimensional cchanges

Measurement of flexural strength of samples was tested by using a three-point bending test in an INSTRON universal testing machine(Figure 4).

Figure 4: 3 point bending test in UTM

The samples were subjected to progressive loading from 1500g (14.71 N) to 5000g (49.03 N). The samples were placed on the surface of the jig. The jig consisted of two metal supports 50mm apart. Three lines were marked on the surface of the specimen, which faced the operator, one at the middle (at 32.5 mm length from either end of sample) and two coincidings with the supporting bars (at 25 mm distance from the middle of the length of the specimen). These lines guided for the positioning of the specimen during testing. The load was applied at the center of each sample via a rod (which was attached to the movable upper arm of the UTM) 2 m.m. in diameter at a crosshead speed of 5 mm/min. The machine was attached to a computer with software to record the loads at which the samples broke after bending to some extent, which was indicated by a sudden drop in the load. The loads (fracture force) were recorded in newtons (N), and the flexural strength was calculated per the following formula to yield MPa units. The maximum force [N] upon fracture was recorded. The flexural strength was calculated from the equation $\sigma = 3FI / 2bh^2$

F: maximal load (N) exerted on the specimen,

I: The distance (mm) between the supports

b: The width (mm) of the specimen

h: The height (mm) of the specimen

Measurement of the **hardness** of samples was tested by using the shore D microhardness testing machine(Figure 5). In the present study, the samples were placed on the surface of a metal table. Three lines were marked on the surface the specimen which faced the operator, one at the middle (at 32.5 m.m. length from either end of sample), and two at each ends 5mm from the edge of the specimen.

Figure 5: Shore D Durometer

These lines guided for the positioning of the indentor of shore D durometer on the specimen during testing. The machine was attached to a computer with software to record the resistance of a material to permanent surface indentation. During penetration of the indentor tip on the surface of the specimen, beep sound produced indicating the corresponding hardness value was shown by the computer. The durometer readings were recorded 1 second after the indentor application. The hardness values were obtained in "Shore D units". The hardness was measured in these 3 points, and then the average was taken.

Measurement of adaptation and dimensional changes of samples were tested by using vedio inspectory system(Figure 6). This machine magnifies the objects by 67 times. The machine was attached to a computer with software to record the adaptation and dimensional changes of the specimen. The drawing of outer and inner portions of the metal die was done, followed by minimization was done. The metal die values ware used as a reference for measuring the dimensional changes of the samples. The linear dimensional changes were measured at inner portions and also at outer portions of the sample. The adaptation was measured by based on the amount of the raise of samples in the central palatal portion on metal die. The values were obtained in mm.

Figure 6: Video inspectory system

Results

The mean flexural strength of denture base resins cured by conventional water bath and microwave energy were presented in Table 1. The ANOVA test and its corresponding P value < 0.05 explains there is a significant difference of flexural strength among resins. Dpi has better flexural strength, followed by acralyn H and Triplex.

Denture base material	Mean	S.D	P-value
Acralyn-H (Conventional)	69.311	1.756	0.000
Acralyn-H (Microwave)	71.963	2.383	0.000
DPI (Conventional)	72.927	1.190	0.000
DPI (Microwave)	75.095	1.336	0.000
Triplex (Conventional)	65.754	0.948	0.000
Triplex (Microwave)	69.755	2.626	0.000

Table 1: Comparision of flexural strength of resins cured by conventional and microwave method.

The mean hardness of denture base resins cured by conventional water bath and microwave energy was presented in Table 2. The ANOVA test and its corresponding P value < 0.05 explain there is a significant difference of hardness among resins. Dpi has better hardness followed by acralyn H and Triplex.

Denture base material	Mean	S.D	P-value
Acralyn-H (Conventional)	77.213	3.211	0.003
Acralyn-H (Microwave)	77.823	3.794	0.001
DPI (Conventional)	80.873	1.515	0.003
DPI (Microwave)	83.189	2.083	0.001
Triplex (Conventional)	73.13	6.930	0.003
Triplex (Microwave)	75.35	6.206	0.001

Table 2: Comparision of the hardness of resins cured by conventional and microwave method

The mean adaptation of denture base resins cured by conventional water bath and microwave energy were presented in Table 3. The ANOVA test and its corresponding P-value > 0.05 explain there is no significant difference in adaptation among resins. Dpi has better adaptation followed by acralyn H and Triplex.

Denture base material	Mean	S.D	P value
Acralyn-H (Conventional)	0.3612	0.1634	0.1442
Acralyn-H (Microwave)	0.2874	0.1002	0.832
DPI (Conventional)	0.3021	0.0785	0.1442
DPI (Microwave)	0.2685	0.1250	0.832
Triplex (Conventional)	0.4028	0.0631	0.1442
Triplex (Microwave)	0.3035	0.1782	0.832

Table 3: Comparision of adaptation of resins cured by conventional and microwave method

The mean dimensional changes of denture base resins cured by conventional water bath and microwave energy were presented in Table 4. The ANOVA test and its corresponding P value <0.05 for resins polymerized by conventional water and the p value > 0.05 for resins polymerized by microwave energy. It explains the significant difference of dimensional changes among resins polymerized by conventional water bath and no significant difference of dimensional changes among resins polymerized by microwave energy. Dpi has better stability followed by acralyn H and Triplex.

Denture base material	Mean	S.D	P-value
Acralyn-H (Conventional)	32.643	0.409	0.000
Acralyn-H (Microwave)	31.912	0.852	0.223
DPI (Conventional)	31.621	0.589	0.000
DPI (Microwave)	31.416	0.630	0.223
Triplex (Conventional)	32.319	0.493	0.000
Triplex (Microwave)	32.108	1.134	0.223

Table 4: Comparision of dimensional changes of resins cured by conventional and microwave method

Discussion

Polymethyl methacrylate has been the first choice for making the base of complete dentures. The most popular denture base material is heat-cured polymethyl methacrylate (PMMA). It has excellent esthetic properties, adequate strength, low water sorption, and low solubility.[3] The properties of acrylic resins like relatively high strength, hardness, resilience, color stability under all conditions of dental use and insolubility in the oral fluids combine to provide excellent material for fabrication of dentures.

Among two techniques of polymerization, the conventional technique is most commonly used because it is easy and also inexpensive. The advantage with microwave technique is curing time is very less, but it needs a special flask and microwave oven. Rapid cooling and removal from the flask can lead to residual stresses in the denture, which in turn may result in distortion. These distortions may lead to a lack of adaptation and dimensional instability. Therefore, the flask is generally allowed to cool slowly in the air. Polishing is usually carried out wet for the same reason of avoiding a rise in temperature.

Microwave heating is independent of thermal conductivity; therefore, curing cycles involving the application of rapid heat may be used without the development of high exothermic temperature.[4] The major advantages of microwave heating over conventional heating are that the inside and outside of substance are almost equally heated, and the temperature rises rapidly.[4]

In the present study, the samples cured by microwave energy showed better flexural strength, hardness compared with samples cured by the conventional method. An increase in flexural strength, hardness can be explained as the microwaves generate heat within the resin. This results in a more rapid and even polymerization.[10] The resins absorbed less energy before fracture; this was explained as being the result of the fact that the material had a lower molecular weight (shorter polymer chains) because of fast polymerization within a short time.[6] Phillip V.keitz et al[19] (1985) reported that the resins cured by microwave method show better physical properties compared with heat-cured resins. S.G.Ilbay et al[15](1994) reported that the transverse load to fracture microwave cured acrylic was slightly higher than that of conventionally cured acrylic resin. Isma Liza ali et al[20] (2008) reported that heat cure denture base resins show better flexural strength and hardness compared with chemically cured resins.

In the present study, the samples cured by microwave energy showed better dimensional stability and adaptation compared with samples cured by the conventional method. It can be explained the microwave polymerization involves heating the acrylic resin monomer only and not the polymer. This allows a relatively low processing temperature around the material, resulting in little residual monomer and good dimensional accuracy. So it has a lower residual monomer to polymer ratio.[3] The lowest residual monomer obtained as a result of a higher degree of conversion. John L. Naveen yadav[10] (2011) reported that the resin record bases processed by the microwave curing method had slightly better dimensional accuracy than the conventionally processed bases. Rodney et al[1](2004) reported that microwave resins displayed better surface adaptation, hardness, and stiffness.

Conclusion

Within the limitations of the study, it can be concluded that in comparison to the conventionally cured method, the microwave method of polymerizing the resins showed better flexural strength, hardness, adaptation, and dimensional stability. Among the resins, DPI showed better flexural strength, hardness, dimensional stability, and adaptation, followed by Acralyn-H and Triplex.

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