Original Article

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Evaluation of Linear Dimensional Accuracy of Conventional Heat Cure Resin and Microwave Cured Resin: A Comparative Study

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Abstract

Objective: The use of microwave energy has been used in various fields of dentistry, medicine and household appliances. Recently microwave energy has been successfully used in dentistry and plethora of articles has been published. Also included in the field of sterilization, disinfection of dental appliances, drying of gypsum product and polymerization of resin. The objective of this study was to compare the linear dimensional accuracy of conventional heat cure resin to microwave cure resin. *Method:* In this study a standard metal die as per ADA specification NO 12 measuring 65 mm in length,3 mm thickness,10 mm wide was used to plan 30 test specimens. 15 test specimens were prepared from conventional heat cure resin and 15 from microwave cured resin. The specimens were checked and evaluated using digital caliper which has precision of ±0.001 mm. The measurements were compared recorded with standard metal dies. *Result and conclusion:* Linear dimensional accuracy was checked both between and within the group with the ANOVA test and found that accuracy between the groups was 0.148 and 0.004 within the group of the study. Consequently the liner dimensional accuracy of microwave resin were better-quality and advanced to conventional cure resin with p value of 0.000.

Keywords: Denture Base Resins; Conventional Heat Cure Resin; Microwave Cure Resin; Linear Dimensional Accuracy; Polymerization; Metal Dies.

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Introduction

In ancient times materials for dental application were simple in nature, few in number and art of application was elementary often much disappointment with final result. Among the most valuable developments in recent years, has been an acrylic polymer. Acrylic polymers were introduced in 1937 as denture base resin [1]. It gained popularity because of its excellent physical and chemical properties. Their use is widely accepted because of its simple technique, good esthetic results and good physical properties. However it had shortcomings like lack of dimensional instability, strength and color. Recently the use of microwave polymerization has several advantages like less processing time, clean method of processing and less distortion but also had disadvantages like special flask, additional expense of microwave and use of microwave resin. Various physical properties like dimensional stability, hardness and porosity have been studied [2] and provide superior to or at par with the conventional cured resin with reduced residual monomer and better dimensional stability.

Retiz [3] described special flask made of fiber reinforced polyester and polycarbon bolts and went on to compare porosity, hardness and strength of identical strips of resin.

In a comparative study of application of microwave energy to the polymerization of denture base resin with conventional water bath curing system with respect to moleculelar weight, conversion of monomer and porosity of acrylic, the following molecular weight were same, convertion of monomer using microwave were substantial. microwave curing at 70 w of 256 minutes minimized porosity [4].

The dimensional accuracy of resin cured by heat cured, heat shock, pour type, visible light and microwave cured in a comparative study of different curing cycle, it was found that dimensional accuracy cured by microwave method were good [5] compared to heat cured, heat shock and was similar to pour type. Dimensional accuracy of microwave cured resin by slow and rapid cooling method were almost same [6,7].

However, in few studies it was found that superior physical properties of microwave were exaggerated. Microwave wave energy found to be acceptable heat source for processing resin. Properties like hardness, strength, and porosity, are same to that of conventional cured resin [8,9]. The popular method measuring the dimensional accuracy is stated to be using the optical measuring apparatus with the use of caliper [10,11].

Objectives

The use of microwave energy has been used in various field of dentistry, medicine and household appliances. Recently microwave energy has been successfully used in dentistry and plethora of articles has been published. Also included in the field of sterilization, disinfection of dental appliances, drying of gypsum product and polymerization of resin. The objective of this study is to compare the linear dimensional accuracy of conventional heat cure resin to microwave cure resin.

Materials and Method

Conventional Curing of Polymethylmethacrylate Method

Standard metal die as per *ADA specification no 12* measuring 65 mm in length, 10 mm in width, 3 mm thickness were used to prepare 30 test specimen. Fifteen test specimen were used to prepare from conventional heat cure resin and fifteen from microwave cured resin. The specimens were measure with digital caliper with accuracy of ± 0.001 mm .The measurement were recorded and compared with the standard metal die.

Preparation of Test Specimen

Conventional method

Investment: The standard metal die (Fig. 1) were invested in dental stone(dental stone TYPE IV dutta stone) by vaccume mixing in dental flask. Each flask pour was allowed to set for 45 minutes, separating media(make DPI) applied to investing layer, counter pour allowed to set for 45 minutes, the flask was opened and metal dies removed without disturbing the margins of the mould.

Packing: The mixture of polymer and monomer resin (DPI heat cure resin (Fig. 2)was prepared in the ratio of 3:1 by volume in air tight container (Fig. 3). When the mixture reached the dough stage, the mold was packed, one trial closure was done (Hydraulic bench press KAVO)(Fig. 4)

Bench curing: Thirty minutes bench curing was done before polymerization starts

Curing: Samples were processed by placing the flask in water for one hour from room temperature to 74 c followed by thirty minutes at 100 C (acryliser: EWL5518, KAVO,Germany) (Fig. 5).

Bench cooling: After processing the flask is removed from the water bath and allowed to cool slowly from ware bath temperature to room temperature. After bench cooling ,deflasking done with care to avoid damage to the margins. It is done with the saw and spiral blade cut through the stone that encloses the specimen and the specimen are removed

Testing procedure: Specimen, so prepared were measured for the dimensional accuracy. The specimens were measured along the longest side using digital vernier caliper for linear change (Fig. 6) *(Electronic digital caliper zoo company, Japan).*

Fig. 1:

Fig. 2:

Fig. 3:

Fig. 4:

Fig. 5:

Fig. 6:

Preparation of test specimens by microwave method

Fifteen specimens were prepared as described above.

Investment: A specially fabricated fiber reinforced plastic flask (Fig. 7) was used to for microwave curing. Flasking were similar to that of conventional method. The standard metal die were invested in dental stone by vacuum mixing in dental flask. Each flask pour was allowed to set for 45 minuts, separating media applied to investing layer, counter pour allowed to set for 45 minuts, the flask was opened and metal dies removed without disturbing the margins of the mould.

Packing: The mixture of polymer and monomer resin was prepared in the ratio of 3:1 by volume in air tight container. When the mixture reached the dough stage, the mold was packed. The upper and lower flask (Fiber reinforced plastic flask with plastic nuts and bolts supreme fiber glass INC Mumbai) (Fig. 8) were assembled with metal bolts securing the position of upper and lower halves of the flask during trial closure hydraulic bench press was used to apply pressure ,clamp was tightened slowly to avoid damage of breaking the fiber reinforced plastic flask until excess flash flow outside the flask. The flask, were opened and excess was cut with a carver. After trial closure metal bolts maintaining position of upper and lower halves of the flask were replaced with plastic bolts and washers and tightened with nuts securely.

Bench curing: Thirty miniuts before polymerization starts

Curing: Resin was microwave (BPL microwave ovenModel no 600 tmco/b;0178 with max power output 800 w) irradiated for 3 minuts at 495 w since the power level setting of 500 w as recommended by manufactures was not possible in present model of oven (Fig. 9).

Bench cooling: After processing the flask is removed from the water bath and allowed to cool slowly from ware bath temperature to room tempratrature. After bench cooling ,deflasking done with care to avoid damage to the margins. It is done with the saw and spiral blade cut through the stone that encloses the specimen and the specimen are removed

Testing procedures: Specimens so prepared were measured for dimensional accuracy across the longest side by using a digital caliper, the measurements for linear change were recorded (Fig. 10).

Fig. 7:

Fig. 8:

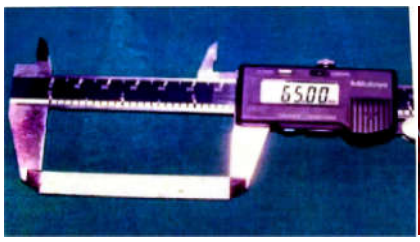

Fig. 9:

Fig. 10:

Results

The aim of this study was to compare linear dimensional accuracy of conventional water bath cure resin and microwave cured resin and compare it to the standard metal die

The data entered in the computer *software excel* 2000 and analyzed by using *Statistica and SPPS statistical software*. Descriptive data that included mean, standard deviation was calculated for each group. Two way *ANOVA* was preformed for linear dimensional accuracy between group and within group. *DUNCAN analysis* was done for each groups

The linear dimensional changes of all acrylicresin was measured across longest site using electronic digital caliper with accuracy 0.01 mm.

The finding of this study are represented in Table 1,2,3 & 4.

Table 1, Showed the values of conventional cured and microwave cured reins and number of test samples were fifteen.

Table 2, Showed descriptive analysis of linear dimensional accuracy among three grips I.e. metal die, conventional and microwave cured resin and mean deviation were calculated.

Table 3, shows analysis of *variance ANOVA* was performed after the mean of standers deviation .A p value of <0.005 is considered to be statistically significant. Obtained *p value is 0.000*. The ratio of sum of squares and mean of squares between the group and within the group was done. It was found that microwave cured resin were significant than conventional cure resins.

Table 4, shows *Duncan* analysis for linear dimensional accuracy for conventional, microwave and standard metal die. It was found that linear dimensional accuracy of microwave ware significant (64.9087) when compared to conventional cure resins within the test group.

Table 1: the values of conventional cured and microwave cured reins

1	**65.00**	**64.77**	**64.87**
2	65.00	64.70	64.95
3	65.00	64.88	64.77
4	65.00	64.88	64.88
5	65.00	64.87	64.85
6	65.00	64.78	64.90
7	65.00	64.77	64.88
8	6500	64.77	64.95
9	65.00	64.70	65.00
10	65.00	64.80	64.99
11	65.00	64.87	64.99
12	65.00	64.77	64.95
13	65.00	64.70	64.88
14	6500	64.88	64.77
15	65.00	64.88	64.00

Table 2: Descriptive Linear dimensional accuracy

groups	**N**	**Mean**	**STD. Deviation**	**STD. Error**
Stander metal die	15	65.000	.000	.000
Conventional heat cure	15	64.8013	.0704	.0182
Microwave cured resin	15	64.9087	.0761	.0196
total	45	64.9033	.1008	.0150

Table 3: Linear dimensional Accuracy

source	**Sun of squares**	**Df**	**Mean square**	**f**	**sig**
Between groups	.297	2	.148	41.436	.000
Within groups	.150	42	.004		
total	.447	44			

Table 4: Duncan analysis

Gropus		**Subset for ALPHA=.05**		
Convebtional heat cure	15	64.8013		
Microwave cured resin	15		64.9087	
Standared metal die	15			65.0000
Sig		1.000	1.000	1.000

Means for gropus in homogeneous subsets ar displayed.

A. Uses harmonic mean sample=15.000

Discussion

In the year 1937 acrylic resin were introduce to dentistry and probably the most research topic in dentistry, such research are usually concerned with physical and manipulative properties and technique and their effect on physical properties.

One of the most important properties is dimensional change. There are two dimensional changes recognized which are unavoidable active in the acrylic resin namely shrinkage which occur during processing and subsequent expansion upon immersion in water.

Petyon, Sadori and *Hamada* [1] studied showed that linear dimensional shrinkage value for 0.26% to 1.20% but are considered to on average approximately 0.50%.

The theory of curing shrinkage is presented by skinner and copper on assumption that it is entirely thermal in nature and for a given resin it will depend on the temperature at which the resin becomes sufficiently rigid to contract thermally [12,13].

Microwaves are a form of high frequency radio wave length of approximately 12 cmts. The microwave region extends from 3,00,000 mega cycles per second .This correspond to wave length longer than infrared rays but shorter than those radio and TV.

Electricity is converted into microwave energy by generator called megatron tube. Domestic microwave ovens produces microwave of 2450 Htz. This mean electrostatic field is generated which changes the direction 2450 times per second. From the megatron tube microwave energy is transmitted oven cavity along straight line. The microwave produces typical characteristics.

When microwave comes in contact with object to be heated anyone or combination of fallowing three changes occur [13].

- reflection from the surface
- transmission through the surface

- absorption into the surface Reflection

Metal surface reflect microwaves and because there is no absorption, no heating occurs. This is the reason why the interior is either epoxy coated stainless steel or stainless steel. The microwaves produce are kept inside and evenly distributed throughout the object when heated with the help of continuous turn table.

When microwave hits metal, spark results discharging static electricity which is called as arching. Hence metal flask used for conventional curing cannot be used in microwave oven for curing acrylics. Microwave safe translucent flask made from fiber reinforced plastics, high resistance ceramic or unbreakable glass which are to be secured with polycarbon or polyethylene nuts should be used.

Reinforcing plastic matrix with a high strength fiber material results in formation of fiber reinforced plastic. Which have low co efficient of thermal expansion, high dimensional stability. low dielectric constant, non inflammability and chemical resistance.

Transmission, substance such has paper, glass and plastic transmitte microwave energy and do not become hot. Fiber reinforced plastic neoceramic or reinforced fiber glass material flasked with polycarbon nut bolt are recommend which transmit microwave energy, do not become hot expect from the heat of acrylic and stone surrounding,

Adsorption, ant material which can be heated by microwave has polarized molecules. This means that one end of each molecule has a slight positive charge while other has slight negative charge. Since microwaves produced an electrostatic field which changes rapidly direction, polarized molecules are flipped over rapidly and generated heat due to molecular friction which produce heat energy which is gradually conducted throughout the acrylic resin dough packed in the mould. The presented study was conducted to compare linear dimensional accuracy between conventional water bath and microwave resin.

In this study Standard metal die as per ADA specification no 12 measuring 65 mm in lengght, 10 mm in width, 3 mm thickness were used to prepare 30 test specimen. Fifteen test specimen were used to prepare from conventional heat cure resin and fifteen from microwave cured resin. The specimens were measure with digital caliper with accuracy of ±0.001 mm. The measurement were recorded and compared with the standard metal die.

The result of the study showed that specimens cured by microwave were statistically significant when compared to conventional resins.

Microwave act only on monomer which decreases in same proportion as polymerization increases. Therefore the same amount of energy is absorbed by less and less monomer making the molecules increasingly active which leads to complete polymerization of resin. It seems that the difference of residual monomer ratio between the classical and the microwave curing method lies in the way monomer molecules are moved into the network of polymer molecules. In conventional method monomer molecules are moved by thermic shock they receive from other molecules and their movements are only consequence of outside heat. In microwave method monomer molecules are moved by high frequency electromagnetic field, their movements are the cause of the internal heat and heat is only the consequence of their movements.

When comparing conventional and microwave methods there is difference in temperature gradient within the gypsum mold between the two methods. Large temperature discrepancy exists between the temperature in the centre and at the edge of the gypsum for water bath cure samples, no such difference exists within the gypsum mold of the microwave cure samples. This small temperature gradient in the gypsum investment resulted in good dimensional accuracy of resin cured by microwave method

Conclusion

Acrylic resin polymers have been most commonly used to make removable complete and partial denture. The success of complete denture depends on selection of denture base material is an important criterion because it should have the ability to reproduce the original impression details and ensure accuracy of fit.

It has few short comings such as poor dimensional stability, porosity, less strength in a countieous search for improved methods to process methylmethacrylte, various techniques have been developed recently microwave energy is used to polymerize polymethylmethacrylate which has advantages such has less processing time, clean method of processing. Various physical properties have found to be equal or superior to conventional cured resin

Therefore this study is directed-

To compare linear dimensional accuracy of conventional heat cured and microwave cured resins

In this study Standard metal die as per ADA specification no 12 measuring 65 mm in lengght, 10 mm in width, 3 mm thickness were used to prepare 30 test specimen. Fifteen test specimen were used to prepare from conventional heat cure resin and Fifteen from microwave cured resin. The specimens were measure with digital caliper with accuracy of ±0.001 mm. The measurement were recorded and compared with the stander metal die.

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