Comparative Evaluation of Dimensional Changes for Four Different Types of Heat Activated Denture Base Resins Before and After Exposure to Electron Beam Irradiation: An Invitro Study

Dr. Priyanka. Jain Sikka[1], Dr. Ritha. Kumari[2], Dr. Rohan. Sikka[3], Mr. V C Petwal[4], Dr Nikhil Srivastava[5], Dr. Priyanka Jain Sikka[6]

[1] *BDS, M.Sc Dental Materials, PhD Student, AB shetty Dental College, Mangalore, India*
[2] *Professor, AB Shetty Dental College, Mangalore, India*
[3] *Professor, PDM Dental College, Bahadurgarh, India*
[4] *RRCAT, Indore, India*
[5] *Dean, Subharti Dental College, Meerut, India*
[6] *F-32, Rattan Park, Delhi*

Email: [1]priyanka57doc@gmail.com, [2]ritha.rai@gmail.com, [3]drrohansikka@gmail.com, [4]vikash@rrcat.gov.in, [6]priyanka57doc@gmail.com

Abstract: ***Background-Removable dentures have been used extensively for the rehabilitation of completely and partially edentulous patients. The success of these prostheses greatly depends on the retention, support and stability. The major objective in the fabrication of complete denture and distal extension partial denture is to attain a denture base that conforms to the supporting tissues with a high degree of accuracy. The PMMA is commonly used as a removable prosthesis material and success of this prosthesis depends on retention, support and stability. The objective in fabrication of complete denture is to obtain denture bases with least dimensional changes which is common reason for relining of them. Electron beam radiation had been used recently but at higher dosage it shows reduction in properties. The aim of this study is to comparative evaluate the Linear dimensional changes of four different types of denture base resins before and after irradiation with electron beam with a low energy dose of maximum up to 50 KGy.***

Methods- Linear dimensional changes of denture base resins before and after exposure to electron beam irradiation post-curing were studied. Four different denture base resins were used with commercial names as, DPI, Trevalon, Trevalon HI, and Meliodent heat activated acrylic resins and they were compared with each other. The irradiated denture base resins are compared with non-radiated standard groups.

Results-Our study presented that PMMA-based denture showed better dimensions up to 20kGy after irradiation with electron beam. As crosslinking occurs at low dosage during irradiation and further C–C bonds are split off and the polymeric structure starts to break down at High dosage of radiation.

Conclusions-Linear dimensional properties DPI heat cure acrylic resin, Trevalon, Trevalon HI, and Meliodent heat cure acrylic resins can be altered by the lower dosage of electron beam irradiation. By comparing the Linear dimensional change of all heat activated denture base resins, with linear dimensional change of all heat cure denture base resins before irradiation, it was observed that – irradiated heat cure denture base resins

show change in results. But Linear Dimensional changes can be reduced only up to lower dosage up to 20kGy further it start getting reduced.

Keywords: Electron beam Radiation, Denture Base, Heat Cure, Linear Dimensions, Radiation, Shrinkage, denture base adaptation

1. INTRODUCTION:

The heat-activated acrylic resin is commonly used for denture base fabrication. The PMMA was first introduced as denture base materials in 1937 and it is commonly used for denture base fabrication nowadays because of its Mechanical, esthetic, physical properties and manipulability.[1,2] Both heat-activated acrylic resin and Chemical activated resins shows unavoidable polymerization shrinkage. The volumetric shrinkage of the heat-activated acrylic resin is about 8%. But it will be distributed uniformly over all surfaces of the denture, so the fit of the denture to the master cast is not so seriously affected. The volumetric shrinkage, due to polymerization contraction, probably contributes very little to the linear shrinkage. It appears that thermal shrinkage of the resin is the chief contributor to the linear shrinkage phenomenon. The linear shrinkages of various denture base materials are reported as from 0.2 to 0.5 %.11.[3]

There are some disagreements between the cured denture base and the master cast because of polymerization shrinkage. Previous studies focused on dimensional changes of the processed acrylic resin.[4] Takamata et al reported the adaptation of processed acrylic resin dentures by measuring gap between the processed denture and the master cast using the micrometer-slide measuring microscope.[5]Sykora et al studied the adaptation of denture bases by the traveling microscope.[6]

Kawara et al reported the shrinkage behavior of heat-cured resin with different processing methods by the strain gauge method. This study revealed that the shrinkage of heat-cured resin was mainly thermal shrinkage and low-temperature curing method showed average 64% shrinkage of that in the specimen processed by the conventional method.[7,8]

A modern method to improve the properties of polymers is high-energy dose irradiation. The mechanism of crosslinking and Chain breakage by irradiation has been studied for years. However, there is still no agreement as to its exact nature.[9-12] Familiarity with physical, mechanical, chemical, biological and manipulative procedures is therefore overbearing if reasonably satisfactory results must be obtained from the use of the material.[13,14]

In this study, four commercially available heat-acrylic resins cured by conventional curing cycle were investigated. Further they were exposed to Electron beam radiation at lower dosage. The purpose of this study was to find that which among four types show least dimensional changes along with comparison with radiated samples.

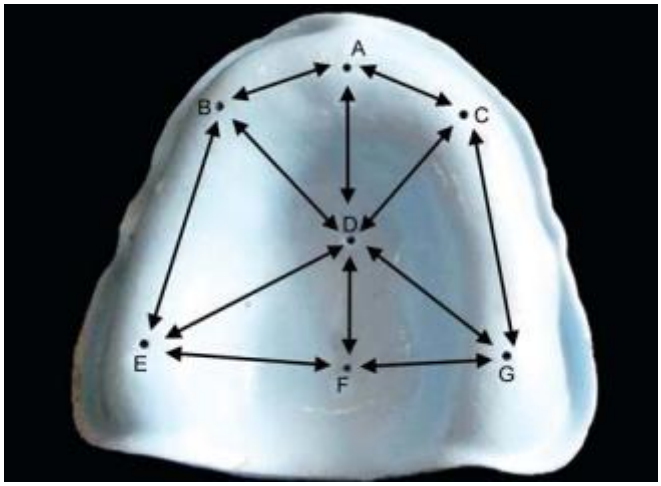
2. MATERIALS AND METHODS-

Heat cure acrylic resin	DPI heat cure	Trevalon HI	Trevalon	Meliodent
Number	80	80	80	80

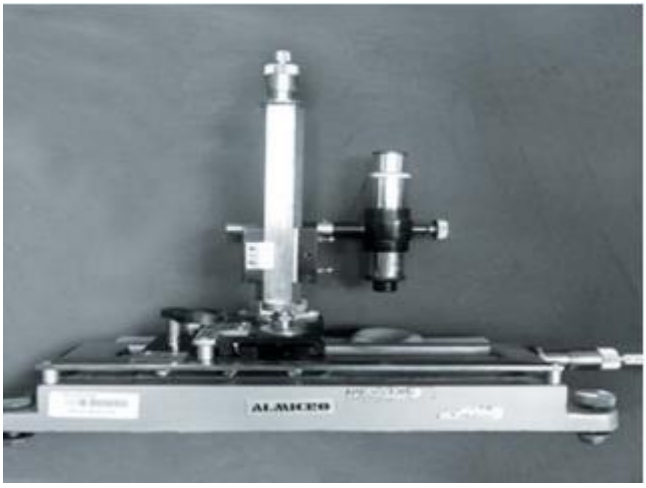
A metal edentulous maxillary model with four reference points at incisive papilla (A), mid-palate area in front of posterior palatal seal area (B), left and right tuberosities (C and D) was used]. The metal model was duplicated using polyvinyl siloxane to prepare 80 casts with type III dental stone.

Fabrication of Thermoplastic vacuum sheets is done over metallic denture which is 4mm from all the sides. Over this using clear cold cure acrylic resin template of 2mm thick evenly is fabricated.

Several reference points were taken
A-Incisive Papilla
B-Canine on both sides
C-Mid point on tuberosity on each side
D-Mid-point joining tuberosity
E-Mid-point joining between A and F



These points were transferred to transfer Template using parallel component of surveyor using 0.5mm diamond pointer.



Distances between all these reference points was measured using travelling microscope and further to compare it after processing of dentures.
320 casts (Group I-80 to Group VI- 80each) of heat cure acrylic resins were prepared (40 for each DPI heat cure, Trevalon HI, Trevalon heat cure and Meliodent heat cure) with wax bases were invested into flasks. After removing the wax with boiling water and separating medium application, the heat-polymerized resins including Meliodent, DPI, Trevalon and Trevalon HI were prepared, poured and processed at 70°C for 2 h with a terminal boiling of 30 min. Then, the flasks were left in the water bath to cool completely. After de-flasking, the excess resins and beads in the intaglio surfaces of denture bases were removed. Again, after processing these distances is measured using transfer template. Then samples were stored in water for 7 days and sent for exposure to electron beam irradiation at a dose of 5, 10, 15, 20,25,35 and 50KGy with energy of 7.7MeV and current of 400Ma with pulse width of 10 microsecond. These marks were compared using various radiation doses from5-50 kilo gray.
In each of test following dosage and time of exposure was done-

Properties	DOSE	MONITORING UNIT	TIME OF EXPOSURE
Linear Dimensional Changes	5KGy	7156MU	353
	10KGy	14312MU	701
	15kGy	21468 MU	1054
	20kGy	28624MU	1404.7
	25kGy	35780MU	1752.8
	35kGy	50092MU	2444.5
	50kGy	71560MU	3501.1

3. RESULTS

Linear Dimensional change- It was observed by Mean, Tukey HSD Multiple comparison and One-way ANOVA method
It was observed that there is reduction in dimension accuracy up to 20KGy but after that there is not much change seen for all the different types of heat activated denture base resins.

Linear Dimensional changes

TYPE OF MATERIAL	DPI HEAT CURE	MELIODENT	TREVALON	TREVALON HI
MEAN %	1.23%	1.54%	1.32%	1.05%
5KGy	1.20%	1.50%	1.32%	0.98%
10KGy	1.18%	1.48%	1.29%	0.97%
15KGy	1.10%	1.46%	1.27%	0.95%
20KGy	1.05%	1.40%	1.25%	0.93%
25KGy	1.05%	1.35%	1.24%	0.90%
35KGy	1.05%	1.32%	1.27%	0.88%
50KGy	1.05%	1.30%	1.25%	0.85%

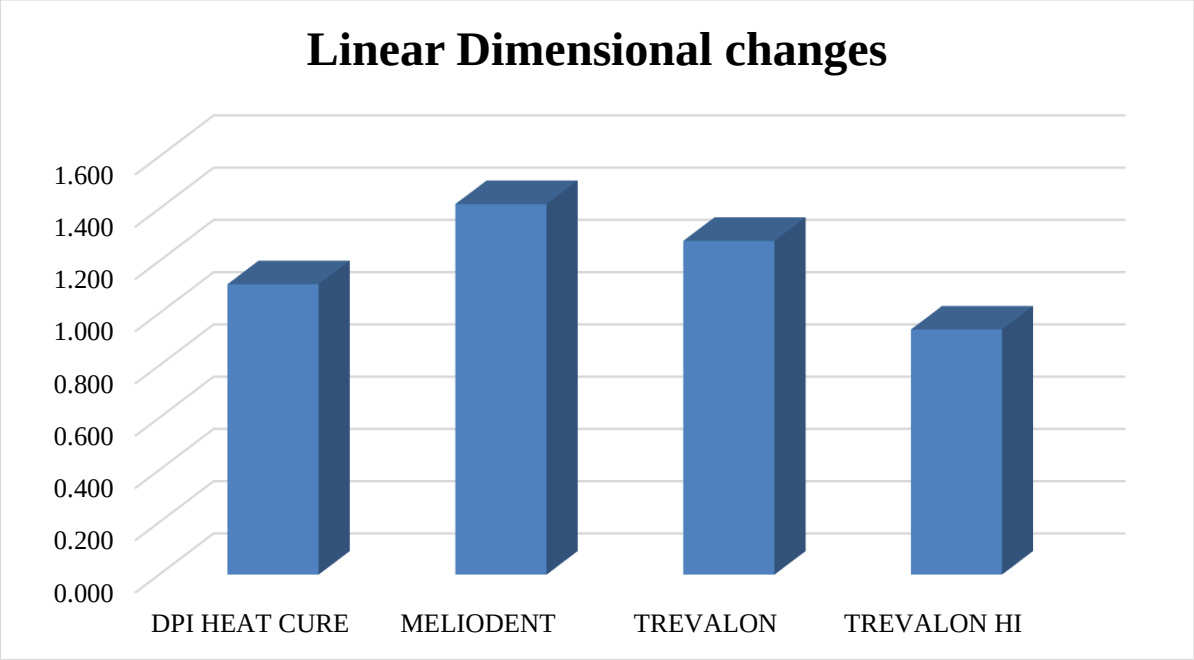


Table-2 (Comparison between groups)

		N	Mean	Std. Deviation	Minimum	Maximum	F-value	p-value
LDC_Std	DPI HEAT CURE	10	1.2250	0.0354	1.1700	1.2800	222.548	<0.001
	MELIODENT	10	1.5360	0.0369	1.4800	1.5900		
	TREVALON	10	1.3210	0.0509	1.2400	1.4000		
	TREVALON HI	10	1.0500	0.0467	0.9700	1.1200		
	Total	40	1.2830	0.1824	0.9700	1.5900		
LDC_5KGy	DPI HEAT CURE	10	1.2010	0.0409	1.1400	1.2600	138.177	<0.001
	MELIODENT	10	1.5030	0.0445	1.4400	1.5700		
	TREVALON	10	1.3220	0.0932	1.1600	1.4500		
	TREVALON HI	10	0.9790	0.0407	0.9200	1.0300		
	Total	40	1.2513	0.2010	0.9200	1.5700		
LDC_10KGy	DPI HEAT CURE	10	1.1770	0.0298	1.1300	1.2200	136.025	<0.001
	MELIODENT	10	1.4780	0.0426	1.4200	1.5400		
	TREVALON	10	1.2920	0.0948	1.1300	1.4200		
	TREVALON HI	10	0.9690	0.0407	0.9100	1.0200		
	Total	40	1.2290	0.1950	0.9100	1.5400		
LDC_15KGy	DPI HEAT CURE	10	1.1000	0.0377	1.0500	1.1500	311.055	<0.001
	MELIODENT	10	1.4580	0.0230	1.4200	1.5000		
	TREVALON	10	1.2710	0.0509	1.1900	1.3500		
	TREVALON HI	10	0.9490	0.0407	0.8900	1.0000		
	Total	40	1.1945	0.1962	0.8900	1.5000		
LDC_20KGy	DPI HEAT CURE	10	1.0500	0.0258	1.0100	1.0900	105.469	<0.001
	MELIODENT	10	1.4000	0.0374	1.3500	1.4600		
	TREVALON	10	1.2510	0.1074	1.0900	1.4100		
	TREVALON HI	10	0.9300	0.0542	0.8500	1.0100		
	Total	40	1.1578	0.1933	0.8500	1.4600		
LDC_25KGy	DPI HEAT CURE	10	1.0450	0.0227	1.0100	1.0800	234.942	<0.001
	MELIODENT	10	1.3540	0.0303	1.3100	1.4000		
	TREVALON	10	1.2410	0.0509	1.1600	1.3200		
	TREVALON HI	10	0.9000	0.0542	0.8200	0.9800		
	Total	40	1.1350	0.1817	0.8200	1.4000		
LDC_35KGy	DPI HEAT CURE	10	1.0500	0.0231	1.0100	1.0900	121.422	<0.001
	MELIODENT	10	1.3170	0.0320	1.2700	1.3600		
	TREVALON	10	1.2710	0.0954	1.1100	1.3900		
	TREVALON HI	10	0.8800	0.0542	0.8000	0.9600		
	Total	40	1.1295	0.1867	0.8000	1.3900		
LDC_50KGy	DPI HEAT CURE	10	1.0460	0.0212	1.0200	1.0800	118.278	<0.001
	MELIODENT	10	1.3020	0.0447	1.2400	1.3700		
	TREVALON	10	1.2510	0.0954	1.0900	1.3700		
	TREVALON HI	10	0.8500	0.0542	0.7700	0.9300		
	Total	40	1.1123	0.1904	0.7700	1.3700		
	Table -2 Comparison between groups							

4. DISCUSSION-

Different methods of processing denture base were devised to overcome the problems of the convention- al method, however each of these methods has some disadvantages that make it difficult for dentist or technician to choose.

DaBreo EL etal studied on linear dimensional change of heat cure, self- cure and light cure denture base resins and found that the heat cured resin (short curing) exhibited the greatest dimensional change among all the three.[15] Pavan etal evaluated the influence of microwave treatment on dimensional accuracy along the posterior palatal border of maxillary acrylic resin denture bases processed by water bath curing. No statistically significant differences were observed between the control group and group II.[16]

There are different ways to improve the mechanical properties of PMMA. These ways include replacing PMMA with an alternative material; chemically modifying it; and reinforcing the PMMA with other materials. Also, different denture designs have been made to decrease stress such as increasing the thickness of the denture base. [17]

Jadhav et al found microwave PMMA has higher impact strength than conventional PMMA.[18] However Al-Dobaei et al concluded microwave curing technique increased the flexural strength of the acrylic resin but reduced its impact strength.[19] Compagnoni reported same porosity between micro- wave and conventional heat-polymerized denture base resin. Although studies on this technique continue, but because of the expensive equipment, microwave technique could not be used as a routine in laboratories.[20]

However, use of different radiation like microwave had also improved properties of denture base resins. Based on that Electron beam Irradiation is used because of its advantages when used with varieties of Polymers.[21]

Electron beam irradiation is reported to increase the stiffness of polymers as well as the links between polymer chains (Behr et al., 2006). Two types of irradiation-initiated reaction can be defined: chain linkage and chain breakage.[22] During chemical reaction, radicals, which induce chain linkage, are initiated from several distinct points. The polymeric chain then increases, but the chain linkage is not equally distributed in the polymer. It has been demonstrated that irradiation initiates the radical build-up of all components of a polymer (Behr et al., 2006). For that reason, the entire polymer may simultaneously be newly arranged and crosslinked when irradiated.[22,23]

The free radicals can recombine establishing the crosslinks. The degree of crosslinking be contingent upon the polymer and radiation dose. One of the assistances of using irradiation for crosslinking is that the degree of crosslinking can be effortlessly controlled by the amount of dose. Furthermore, oxidation can continue after irradiation prompting changes in properties with time.[24]

Analysis of the data in the present study offers some insight into the influence of electron beam post-curing on polymer PMMA. Nevertheless, polymethyl methacrylate (PMMA) is often described in the literature as a thermoplastic polymer, which tends towards chain breakage during irradiation (Behr et al., 2005b, c).[22] It has been demonstrated that the properties of mostly PMMA-based denture resins could be improved using electron beam irradiation, although as the radiation dose increases above 25kGy properties reduced. It appears that beyond 25kGy radiation dosage, C–C bonds are split off and the polymeric structure starts to break down. The findings of the present study demonstrate that all the investigated denture base resins show improvement in Dimensional properties. The free radicals can recombine establishing the crosslinks. The degree of crosslinking be contingent upon the polymer and radiation dose. One of the assistances of using irradiation for crosslinking is that the degree of crosslinking can be effortlessly controlled by the amount of

dose. Furthermore, oxidation can continue after irradiation instigating changes in properties with time.

In this study as chain crosslinking take place maximum up to 20kGy radiation dose which has improved the dimensions of PMMA but beyond that there is no further change which means that no cross linking or chain breakage is taking place beyond that dosage.

5. CONCLUSION-

Following are the finding of my study

1. The findings of the present study demonstrate that though mechanical properties of polymer denture base resins can be modified by electron beam irradiation but at lower dosage.
2. There is effect on physical properties after exposure only up to 20 Kilo gray of radiation dose and before exposure on all different type of materials.
3. Trevalon HI has shown least dimensional changes whereas as Meliodent has shown highest dimensional changes in non-radiated state.
4. Unlike other mechanical properties, there is no change in Dimensions beyond 20 kGy though it is better than standard material in all the different categories.

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