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RESEARCH ARTICLE

COMPARATIVE EVALUATION OF HARDNESS AND SURFACE ROUGHNESS AFTER DIFFERENT COOLING PROCEDURES OF HEAT CURE DENTURE BASE MATERIALS

Dr. P. Akhila, Dr. Y. Ravi Shankar, Dr. Penusha Deepthi, Dr. P. Shameen Kumar, Dr. R. Hima Bindu and Dr. K. Vasudha

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Abstract

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Aim: To evaluate the influence of different cooling procedures on mechanical properties of DPI & LUCITONE heat cure poly methyl methacrylate denturebase materials before andafter 1year of brushing simulation.

Materials And Methods: A total of 100 specimens were prepared using two heat cure denture base materials i.e, DPI and LUCITONE. The specimens in each group were subdivided into five groups (n=10) based on the cooling procedure followed: A: Flask remains in water bath till room temperature B: Remove flask from water bath, bench cool for 30min and then cool under running water for 15min C: Remove flask from water bath, bench cool for 10min and then cool under running water for 15min D: Remove flask from water bath and bench cool till room temperature E: Remove the flask from water bath and cool under running water for 15 minutes.After finishing and polishing, samples were placed in a brushing machine to simulate one year of mechanical cleansing. The specimens were tested for surface roughness with profilometer and hardness with Vickers hardness tester before and after brushing. Results were statistically analysed by two and one- way Analysis of variance (ANOVA) plus Tukey post hoc tests.

Results: Specimens with type C(Remove flask from water bath, bench cool for 10min and then cool under running water for 15min)cooling procedures have high hardness values, among whichLucitone showed better properties. Surface roughness did not show significant changes among different groups. Brushing did not significantly affect surface roughness and hardness of denture base materials.

Conclusion: Two of the treatments tested, Treatment C: bench-cooling for 10 min and cooling under running water for 15min and Treatment A: cooling in water-bath till room temperature provided the highest hardness values.

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Introduction:-

Denture bases are commonly made from acrylic resins, which were introduced by Dr. Walter Wright back in 1937. Denture base resins are usually composed of pre-polymerizedpolymethylmethacrylate (PMMA) powder particles, which are mixed with monomers of methylmethacrylate (MMA) and a cross-linking agent such as ethylene glycol

Corresponding Author:-Dr. P. Akhila

dimethacrylate (EGDMA)[1]. Denture-based materials are classified based on their curing methods into heat cure, cold cure, and microwave cure. Heat cure denture base materials are the most widely used and have excellent mechanical properties. The polymerization of heat-cure denture base materials occurs through a free-radical-initiated reaction[2].

PMMA material is mostly processed by wet heat and compression molding techniques, which deliver dentures with acceptable mechanical properties. However, certain dimensional changes are known to occur in the acrylic resin during or after its processing and inaccuracies tend to occur due to unavoidable changes during fabrication such as variation of coefficient of thermal expansion of methods involved in processing within acrylics,contraction on cooling and polymerization shrinkage due to the release of residual stresses[3].

However, during the polymerization process of heat-cure denture base materials, a considerable amount of heat is generated, which can cause distortion and shrinkage. Cooling procedures arethereforenecessary to minimize the negative effects of the heat generated during the polymerization process[4].

The cooling procedures can be classified into two categories, namely conventional cooling and post-curing cooling[5]. Conventional cooling involves allowing the material to cool down naturally after polymerization.Post-curing cooling involves cooling the material after polymerization in a controlled manner. The cooling can be done under water, airor under pressure. The cooling rate can also be controlled by varying the temperature of the cooling medium [6]. In rapid cooling, the flask is allowed to bench cool for 30 minutes and then placed under running tap water for 30 minutes.

Maintaining denture hygiene is important so as to improve oral health and longevity of removable dentures. Denture cleaning methods include mechanical, chemical and physical.Chemical methods include some peroxide type denture cleansers, but the disadvantage include bleaching, discoloration of the resin and loss of aesthetics[7]. Mechanical cleaning includes brushing along with dentrifice. The bristles of brush and abrasive particles of dentrifice should be considered while using mechanical cleaning.

The present study aims to evaluate the influence of different cooling procedures on the mechanical properties of DPI & LUCITONE heat cure poly methyl methacrylate denture base materials before and after 1year of brushing simulation.

Materials And Methods:-

A total of 100 specimens were prepared using two heat cure denture base materials i.e, DPI and LUCITONE. The specimens in each group were subdivided into five groups (n=10) based on the cooling procedure followed: A: Flask remains in water bath till room temperature B: Remove flask from water bath, bench cool for 30min and then cool under running water for 15min C: Remove flask from water bath, bench cool for 10min and then cool under running water for 15min D: Remove flask from water bath and bench cool till room temperature E: Remove the flask from water bath and cool under running water for 15 minutes.

A stainlesssteel die (FIG 1) was made using a laser cutting machine and CNC machine of dimensions 30mm diameter and 2.5 mm height according to ISO/DIS 1567. The impression of the die was made with high-viscosity rubber base impression material (Dentsply, Aquasil Soft Putty Regular Set). Following the manufacturer's instructions, an equal amount of catalyst and base were manipulated. The manipulated putty material was placed in a rectangular plastic box and stainless-steel dies were placed on it, until the set of putty to create mold space. Three such mold spaces were created in putty with three stainless-steel dies in the plastic box. Wax patterns were fabricated using putty index which were then processed and heat cured. Two commercially available heat cure denture base materials were used in this study, Lucitone 199 and DPI. Heat cure material was mixed in the ratio 3:1 as per manufacturer instructions. Packing was done at dough stage. Longcuring was done followed by cooling procedures as per the groups.

After deflasking the specimen surfaces were wet-ground with SiC papers up to 600 grit-size with Marathon micromotor(FIG 2). A customized brushing machine(FIG 3) for mechanical cleaning was used to simulate cleaning for 2 minutes per day for 1 year where the samples were placed on the housings of the machine and brushing was donewith the brush moving front and back motion on the sample and chlorinated tooth paste was used which was mixed in the water bath in the brushing machine. Hardness was tested using a Vickers testing machine and surface roughness(FIG 4) was tested using a profilometer both before and after brushing.

Results:-

The mean hardness values of DPI and Lucitone heat cure acrylics following different cooling procedures ranged from 11.94 to 3.44 before brushing and 11.81 to 3.13 after brushing(Table 1). One-way ANOVA analysis revelaed no statistically significant differences between the groups (P>0.05).The highest mean hardness value(11.81±2.11) was obtained with Lucitone heat cure acrylic both before and after brushing following type C(Remove flask from water bath, bench cool for 10min and then cool under running water for 15min)cooling procedure.

The lowest mean hardness value (3.13±0.69) was observed with DPI heat cure acrylicboth before and after brushing following the type D(Remove flask from water bath and bench cool till room temperature) cooling procedure. The decreasing order of the hardness value:
C > A > B > E > D

The mean surface roughness values of DPI and Lucitone heat cure acrylics following different cooling procedures ranged from 106.74 to 88.76 before brushing and 107.67 to 89.48 after brushing(Table 2). Highest mean roughness value was observed for DPI heat cure acrylic following type A(Flask remains in water bath till room temperature) cooling procedure both before and after brushing.The lowest mean surface roughness was observed with Lucitone heat cure acrylic following type B (Remove flask from water bath, bench cool for 30min and then cool under running water for 15min) cooling procedure both before and after brushing.

No statistically significant differences were observed among cooling procedures but DPI exhibited the highest surface roughness value when compared to Lucitone heat cure acrylic.

Table 1:- Hardness values of DPI and Lucitone heat cure acrylic before and after brushing following different cooling procedures.

Groups	Cooling procedure	N	Before	After	P value	
Group1 (DPI)	A	10	7.83	7.68		
Group 2(Lucitone)	A	10	8.69	8.57		
Group 3(DPI)	B	10	5.97	5.83		
Group 4(Lucitone)	B	10	6.91	6.85	0.912	
Group 5(DPI)	C	10	8.53	8.25		
Group 6(Lucitone)	C	10	11.94	11.81		
Group 7(DPI)	D	10	3.44	3.13		
Group 8(Lucitone)	D	10	3.92	3.81		
Group 9(DPI)	E	10	4.89	4.88		
Group 10(Lucitone)	E	10	5.49	5.52		

P>0.05 statistically significant differences were not observed between different cooling procedures for both DPI and Lucitone heat cure acrylic

Table 2:- Surface roughness values of DPI and Lucitone heat cure acrylic before and after brushing following different cooling procedures.

Groups	Cooling procedure	N	Before	After	P value	
Group1 (DPI)	A	10	106.74	107.67		
Group 2(Lucitone)	A	10	90.24	91.18		
Group 3(DPI)	B	10	102.49	103.35		
Group 4(Lucitone)	B	10	88.76	89.48	0.823	
Group 5(DPI)	C	10	105.97	106.87		
Group 6(Lucitone)	C	10	91.46	92.51		
Group 7(DPI)	D	10	105.32	106		
Group 8(Lucitone)	D	10	91.79	92.1		
Group 9(DPI)	E	10	103.74	104.84		

Group 10(Lucitone)	E	10	92.93	93.04		

The above table depicts the mean surface roughness values of DPI and Lucitone heat cure acrylics before and after brushing following different cooling procedures. No statistically significant differences were observed between different cooling procedures.

Discussion:-

Heat activated acrylic resin is still the most widely accepted material and is the principal choice when it comes to denture base.Dimensional changes due to polymerization shrinkage are inevitable in heat processed Polymethacrylate (PMMA) denture base, materials[8,9,10].In addition to polymerization shrinkage there is also thermal shrinkage as theprocessed denture cools in the flask. These changes are compensated to some extent by water sorption.The final adaptation of the denture thus, is affected by several factors as 1) Type of acrylic resin; 2) Flask cooling procedures and 3) Water uptake[10,11].

Currently, a variety of differentapproaches are instructed including a combination of different temperature rates, incubation times at specific temperatures, use or not of water baths and different sequences between heating and cooling procedures, with very limited documentation on the advantages offered by each one. Current study included five different cooling procedures in order to evaluate the effect of these different cooling procedures on the mechanical properties of heat cure acrylics.

The cooling rate of heat-cured polymers has been recognized as a means of controlling their crystallinity and shrinkage. PMMA is amorphous because the pendent groups do not allow the molecules to get close to form crystalline bonds; therefore the predominant effect of the cooling rate is on shrinkage, which is associated with ill-fitting dentures[6,10,11].

The denture base materials tested were all based on MMA/ PMMA liquid/powder systems. Differences in the cross-linker quantity and thermal history during curing may affect the crosslinking density and curing capacity of the PMMA polymer, anticipating variations in the mechanical properties.

In the present study samples which were bench cooled i.e, treatment C(Remove flask from water bath, bench cool for 10min and then cool under running water for 15min),A(Flask remains in water bath till room temperature),B(Remove flask from water bath, bench cool for 30min and then cool under running water for 15min)showed better hardness values than the one which were rapidly cooled (treatments D,E) .

It has long been recognized that the least deformation of the prosthesis is attained when gradual post-processing cooling is used (for 12 hours or more).

This is mainly related to the conformation of the polymer chains. When fast cooling rates are used, the polymer chains are highly constrained, with reduced segmental mobility and the resultant residual stresses are high, affecting the dimensional stability and fitting of the prosthesis and the mechanical properties.

In the present study treatment C (Remove flask from water bath, bench cool for 10min and then cool under running water for 15min) showed higher hardness value than the samples with treatment B (Remove flask from water bath, bench cool for 30min and then cool under running water for 15min). The reason for this performance may be related to the quenching after a prolonged bench-cooling period (30 min) in comparison with treatment C(10 min).

In the former, the temperature after 30 min bench-cooling is expected to be lower than the glass transition temperature of PMMA (95 – 105°c), where the original soft, rubbery state becomes a hard, glassy state[12].Quenching in water at a glassy state may induce more internal stresses and affect the mechanical properties tested[13].

This finding is in accordance with Skinner and Cooper and Chen etal., who found higher shrinkage of quenched dentures than bench-cooled ones. An explanation for such a phenomenon can be the greater contraction of the resin compared with that of the gypsum moldduring the fast cooling, which probably placed an extreme elastic strain on the denture. After deflasking, all dentures might have distorted because of the elastic strain released[3].

Mechanical cleaning with the aid of brushing and tooth paste has some disadvantages as the bristles of the brush and abrasive particles of dentifrice cause sliding and rolling wear[13]. Surface of denture resin might be damaged and mass loss might occur. In the present study surface roughness increased after brushing but not significantly. This was in accordance with study conducted by Kyoizumi et al.,[15] as the hardness of the toothbrush bristles, tuft density and tuft material had minimal impact on the surface roughness of denture resins and that changes in the overall roughness depend on the denture material used. Therefore, the polymerization methods used and the materials compositions are factors that can potentially affect the artificial ageing of denture bases[16].Decrease in hardness of the samples might be attributed to slight increase in roughness.

Fig 1:- Stainless Steel Die.

Fig 2:- Heat Cure Acrylic Samples.

Fig 3:- Brushing Of Samples.

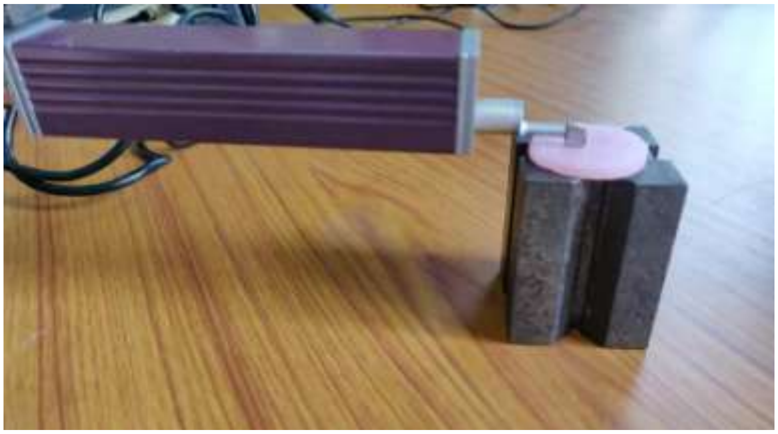

Fig 4:- Surface Roughness Testing.

Conclusion:-

Amongst the cooling methods used for the acrylic specimens, fast cooling in the quenching process induced uneven thermal contraction and greater warpage of denture. Slow cooling of denture resins in water bath or bench cooling resulted in more uniform cooling of dentures and less dimensional changes. Therefore, these treatments may be considered as short(C) Remove flask from water bath, bench cool for 10min and then cool under running water for 15minand long(A)Flask remains in water bath till room temperature,cooling procedures respectively for the denture base polymers tested. Studies have indicated that long-term use of toothbrushes and abrasive paste leads to the formation of scratches leading to increased roughness on the denture surfaces and loss of material over some time. Loss of surface detail ultimately affects the fit of the prosthesis so the use of abrasives on the intaglio surface of the denture is not recommended. Instead,the use of chemical cleansing agents with the aid of fingers is advised.

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