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Effect of different curing times of dry pressure heat curing technique on tensile strength, transverse strength and surface hardness on heat cured acrylic resin

(Dry pressure heat curing technique and curing times)

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ABSTRACT

Aims: The purpose of this study was to evaluate the effect of dry pressure heat curing technique with different curing times on the tensile strength, transverse strength and surface hardness of heat cured acrylic resin as compared with conventional curing technique.

Materials and Methods: Ninety specimens of vertex regular heat cured acrylic resin denture base material were used in this study, curing by two different technique, conventional curing technique and dry pressure curing technique in different times (20, 25, 30, 35, 40 minutes). The tensile strength was measured by Terco universal testing machine, while the transverse strength was measured by using 3 points bending on an Instron testing machine, and the hardness test measured by using Rockwell hardness tester. Mean values were compared statistically with one way analysis of variance and by Duncan's multiple range test to determined the significant different among the groups at $p<0.05$ level of significance.

Results: In comparisons between curing techniques, that there was no significant difference at $p\leq 0.05$ between conventional curing technique and dry pressure curing technique in 30 minutes cycle for all tests used in this study.

Conclusion: The dry pressure heat curing technique at 30 minute cycle has no effect on the tensile strength, transverse strength and surface hardness of heat cure acrylic resin.

Key Words: Heat cured acrylic resin, tensile strength, transverse strength and surface hardness.

INTRODUCTION

The ideal denture base material should possess several key physical attributes. Some of these properties include biocompatibility, good esthetic, high bond strength with available denture teeth, radiopacity, ease of repair and should possess adequate physical and mechanical properties.(1)One of the most widely used materials in prosthetic dentistry is polymethyl methacrylate (PMMA). Excellent appearance, ease in processsing, and repairability, make polymethyl methacrylate as an excellent denture base material.(2) The mechanical properties of denture base materials may undergo changes due to continued polymerization and water uptake, where water absorption into denture base materials act as plasticizer.(3)Polymerizing material under pressure can improve these mechanical properties However, the pressure needed for the procedure is material dependent.(4)Curing processes have been modified in order to improve the physical and mechanical properties of those materials, and also to afford the technical work of the professionals. Different polymerization methods have been used: heat, light and microwave energy.(5)Poly methyl methacrylate resins were molded by using simple compression technique. Polymerization was accomplished by heating the molded material in water bath, with advances in polymer science, new molding and activation techniques have been introduced such as visible light cured, microwave and ivomat activation techniques.(6) In this study used dry pressure curing technique by newly device (pressure curing units).Tensile strength is defined as the resistance of the material to a tensile or stretching force.(7)While tensile stress means the internal induced force that resists the elongation of a material in a direction parallel to the direction of the stresses.(8)The transverse strength of the material is a measure of its stiffness and resistance to fracture. PMMA has acceptable clinical stiffness.(9) The test usually employed to evaluate the transverse strength of acrylic resin simulates the load that affects the maxillary complete denture in situ.(10)Hardness is the resistance of a material to indentation.(11)The low hardness number of acrylic resin base material indicates that these materials may be scratched easily and abraded.(12)

The purpose of this study was to evaluate the effect different curing times of dry pressure heat curing technique on the tensile strength, transverse strength and surface hardness of heat cured acrylic resin as compared with conventional curing technique.

MATERIALS AND METHODS

Ninety samples of heat cured acrylic resin denture base material (Vertex Regular, Holland) were used in this study, divided in six groups fifteen samples for each group). First group curing by conventional curing technique (as control), while remaining groups curing by dry pressure heat curing technique with different curing times (20,25,30,35 and 40 min.). All groups tested by tensile strength, transverse strength and surface hardness test (five samples for each one). The heat cured acrylic resin was selected to evaluate the influence of two different curing techniques and times of curing on the tensile, transverse strength and surface hardness properties of this material. Pressure curing units (Lingchen, Model: YJ-B) was used in this study at 220V, 50 Hz, 600W with frame sizes 280*140*400 at 104°C as shown in Figure (1). Put through the power, turn the heating timer clockwise to primary position (20-25 minutes), wait 20 minutes after the heating power then you can remove the molding boxes and put it in normal temperature water and cooling it according to the manufacturer instructions of device. Powder (polymer) and liquid (monomer) of heat cured acrylic resin have been mixed according to the manufacturer's instruction and packed into stone mold in the metal flask, and then the flask was re-closed and pressed under a hydraulic press 100 bar for fifteen minutes. For conventional curing technique the specimens were cured by water bath according to its manufacturer's instruction of material (90 mints in 73°C then 30 mints in 100°C).While in dry pressure heat curing technique, the specimens were cured for 20, 25,30,35 and 40 min in pressure curing units at 104°C, wait 20 minutes after the heating power then you can remove the flask from device , the flasks were left aside for bench cooling at room temperature before opening; the samples have been removed, finished with engine stone bur, then incubated in distilled water at 37 ±1°C 48 hr for conditioning before testing.[13]

Tensile Strength Test

The samples were constructed with dimensions 90*10*3±0.03mm (length, width, thickness respectively). Then Terco universal testing machine was used to measure the tensile strength of samples as shown in Figure (2).[14]The samples were grasped by two arm of the machine and the amount of force applied was 0.1 Kilo Newton per second continuous increase tension force until fracture of sample occurred in Terco universal testing machine. The results were recorded from a special program on a computer of tensile machine for each sample. The force at failure was recorded in Newton (N) and the true tensile strength value was calculated by the following formula:[14]

Tensile strength = F(N)/A (mm^2)

F= Tension force at Failure (N)A= Cross Section of specimens

Transverse strength test

The samples were prepared with dimension of 65*10*2.5±0.03 (length, width and thickness) respectively.[13] The test was done in air by using 3 points bending on an Instron testing machine. The device was supplied with a central loading plunger and two supports with polished cylindrical surfaces of 3.2 mm in diameter and 50 mm between the supports as shown in the Figures (3 and 4). The supports should be parallel to each other and perpendicular to the central line. The test was carried out with cross head speed of 5 mm/min. The test specimen was held at each end of the two supports and the loading plunger was placed midway between the supports. The specimens were deflected until fracture occurred. The transverse strength was calculated using the following equation:[12]

$S = 3PI / 2bd^2$

S=transverse strength (N/mm^2)=MPaD= depth of specimen (mm)

P= Maximum force exerted on specimen (N)

B=width of specimen (mm)I = distance between supports (mm)

Surface Hardness Test

The samples were prepared with dimensions of 30*15*3± 0.03mm (length, width, and thickness respectively). The samples surfaces were tested for hardness at five different locations, and then the mean was taken for each sample.[15] The test was done by using Rockwell hardness tester, equipped with an indenter in the form of round steel ball of 1\2 inch in diameter. The sample was subjected to fixed minor load of 60kg, then the Rockwell hardness number was recorded after application of this load by 15 sec (according to the instruction of the machine) as shown in Figure (5).

RESULTS

In tensile strength, transverse strength and surface hardness test, the control group had the highest value, while the 20 minutes group had lowest value. The analysis of variance (one way ANOVA)and Duncan multiple range test, were illustrated in Tables (1, 2 and 3) and Figures (6, 7 and 8), revealed that there were a significant difference at $p \leq 0.05$ in tensile strength, transverse strength and surface hardness for heat cured acrylic between different times of dry pressure heat cured (20,25,35 and 40), except within 30 minutes curing times there was no significant difference at $p > 0.05$ as compared with control group.

DISCUSSION

Many studies have reported desirable properties of polymer denture resins such as adequate strength, satisfactory thermal properties, dimensional stability, insolubility in oral fluids, acceptable aesthetics, ease of handling, and moderate cost.(16-18) In order to compare the performance of different denture resins, various mechanical tests can be performed. However, previous investigations have not been in agreement regarding the mechanical properties of these resins.(19, 20)In comparison between different curing times of dry pressure hear curing technique with the conventional curing technique. The samples that cured at times(20 and 25 minutes) in dry pressure heat curing technique (according to the instructions of the device), demonstrated that there were a significant difference in tensile strength, transverse strength and surface hardness properties as compared with conventional method as shown in Tables (1, 2 and 3) and Figures(6, 7 and 8). This result comes in agreement with Al-Tahho, 2013(21) who found that the heat cured acrylic resin significant increased in water sorption and solubility when cured by dry pressure heat curing technique at 25 minutes as compared with conventional curing technique. Due to insufficient time for curing to completed polymerization process, therefore the heat cured acrylic samples have high ratio of residual monomer water solubility and sorption , therefore reduce the mechanical properties (tensile strength, transverse strength and surface hardness), also might be due to the presence of the large number porosities in this material.(22, 23) It was concluded that the time that these materials could be kept under pressure during the polymerization process not enough; so that common defects and internal voids often result. It has been proposed that internal porosities concentrated stresses in the matrix and contributed to the formation of microcracks under loading.(23) It should also be noted that, consistent with manufacturer's recommendations, the dimethacrylate material was polymerized on one side only. Other explanation is that because the time that these materials could be kept during packed and flask under pressure during the polymerization process also not enough these lead to that it was difficult to attain consistently dense specimens and this lead to decrease their mechanical properties.(24)

While the samples that cured at time 30 minutes in dry pressure heat curing technique (over curing time as compared with the instructions of the device),demonstrated that there was no significant difference in these mechanical properties as compared with conventional method, due to these technique done by pressure curing units system, that consist from upper heater, lower heater and press, therefore the curing process of this technique done by heating generation from two side upper and lower heater at same time under pressure with sufficient time for curing at 30 minutes to completed polymerization process (heating the flask from two directions with pressure). While the samples that cured at times (35 and 40 minutes)in dry pressure heat curing technique (over curing time as compared with the instructions of the device), demonstrated that there were a significant difference in these mechanical properties as compared with conventional method as shown in Tables () and Figures. Due to over curing time, over curing time lead to increased the degree of conversion which may serve to increase the bulk flexural and fatigue strength of heat-cured resin then the formation of high ratio of porosity due to over polymerization in the heat cured acrylic samples , therefore reduce the mechanical properties.(24)

CONCLUSION

The dry pressure heat curing technique at 30 minutes cycle has no effect on the tensile strength, transverse strength and surface hardness of heat cure acrylic resin.

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Table (1):) Analysis of Variance (ANOVA) of tensile strength

Groups	Sum Squares	Df	Mean Square	F-value	P-value
Between Groups	314.168	5	62.834	41.699	0.000*
Within Groups	36.164	24	1.507		
Total	350.332	29			

df: Degree of Freedom,*: significant difference at P≤ 0.05 0.05.

Table (2):) Analysis of Variance (ANOVA) of transverse strength

Groups	Sum Squares	Df	Mean Square	F-value	P-value
Between Groups	251.001	5	50.2	40.447	0.000*
Within Groups	29.787	24	1.241		
Total	280.789	29			

df: Degree of Freedom,*: significant difference at P≤ 0.05 0.05.

Table (3):) Analysis of Variance (ANOVA) of surface hardness

Groups	Sum Squares	Df	Mean Square	F-value	P-value
Between Groups	318.567	5	63.713	49.647	0.000*
Within Groups	30.8	24	1.283		
Total	349.367	29			

df: Degree of Freedom,*: significant difference at P≤ 0.05 0.05.

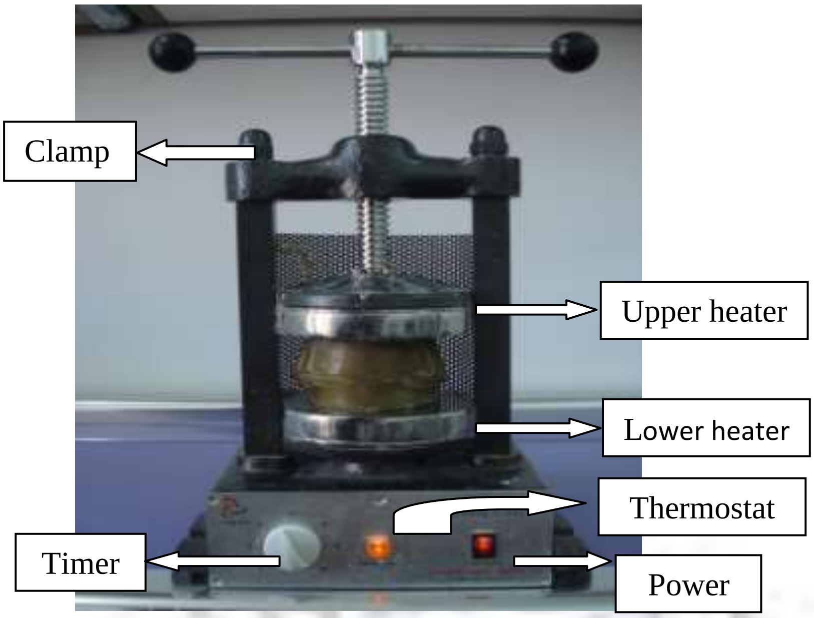

Figure (1): Pressure curing unit

Figure (2): Terco universal testing machine.

Figure (3):Instron testing

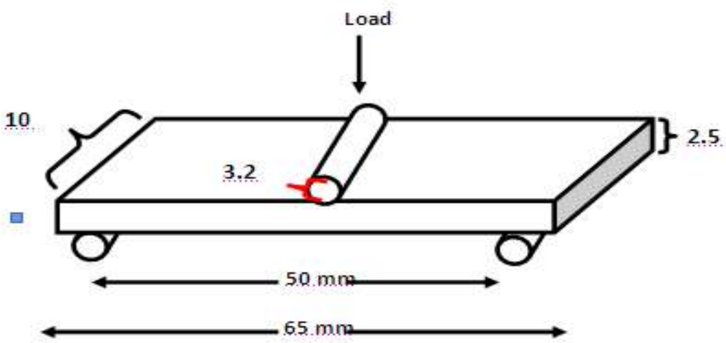

Figure (4): Three Points Bending Test

Figure (5): Indentation hardness testing machine

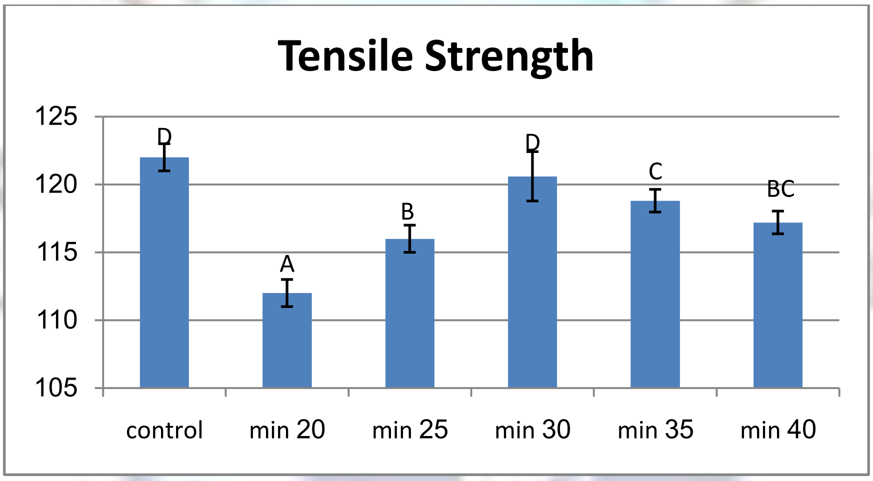

Figure (6): Mean, Std deviation and Duncan's multiple range test of tensile strength, different letters indicates significant differences.

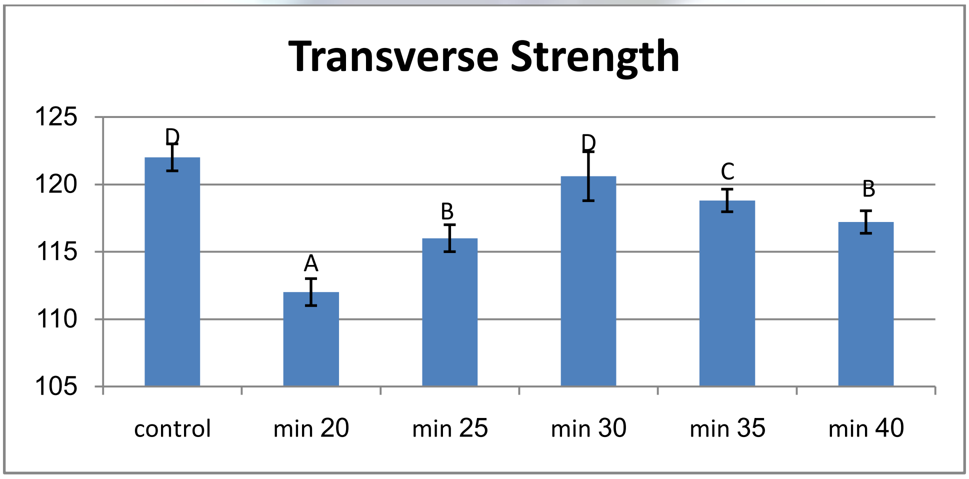

Figure (7): Mean, Std deviation and Duncan's multiple range test of transverse strength, different letters indicates significant differences.

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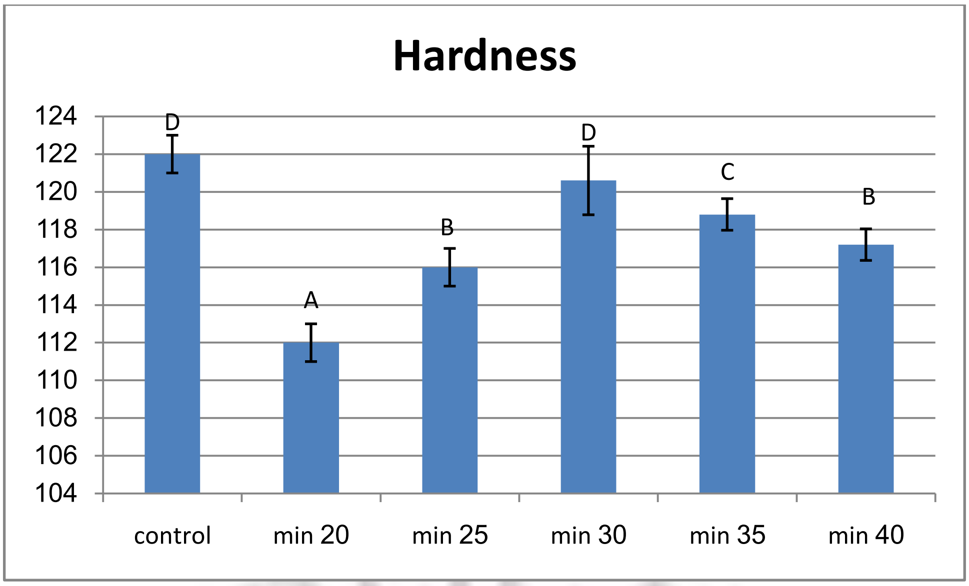

Figure (8): Mean, Std deviation and Duncan's multiple range test of surface hardness, different letters indicates significant differences.