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Temperature Effect on the Hardness of Different types of Resin Denture Base Materials

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Abstract

The cold cured acrylic resin is inferior to heat cured acrylic resin from stand point of strength and degree of polymerization. Many attempts have been made to improve these properties. Because heat affects maturity of the chemical reaction of acrylic resin therefore its maintenance during polymerization will affect the properties of cured resin.

The purpose of this study was to evaluate the effect of increase curing temperature on the hardness of two commercially available cold cured acrylic resin material (Holland and Germany type) in comparison to heat cure resin and to those(cold cure) curing by conventional methods in air at 23°C ± 5°C.

Ninety specimens,10 specimens from heat cure resin curing by water bath(short cycle) and eighty specimens from cold cured acrylic [forty from cold cured acrylic(Holland Type) and forty from cold cured acrylic(Germany type)] were prepared , flasking and packing procedure were done according to manufacturer direction and divided according to processing as follow:20 specimens(10 from Holland type and 10 from Germany type) were processed in air for two hours at 23°C ± 5°C under press (bench curing) as a control, and 60 specimens(30 from Holland type and 30 from Germany type) were processed by ivomat curing device containing water under air pressure 30 Pascal for 15 minutes at different temperature: 40°C, 60°C, and 80°C(10 specimens for each groups) .All specimens were tested for hardness test by shore D device (adigital model) for measuring the indentation hardness of the specimens the test load was set to 50 Newton for shore ((D))which is suitable for acrylic resin material .

Result showed that heat cure resin show the maximum value of hardness (88.8),followed by cold cured acrylic type Germany(polymerized by elevated temperature 80˚C) (88.696) followed by cold cured acrylic type Holland polymerized at 60˚C(88.471). While control group type Germany (polymerized at air bench) recorded the minimum value of hardness (81.83). All groups that polymerized at high temperature: 40°C, 60°C, and 80°C show the higher value of hardness in comparison to those processed by conventional methods (at air bench at 23°C ± 5°C) with significant and highly significant differences. There were highly significant differences between heat cure acrylic and cold cure (both types) processed by conventional methods and with cold cure Holland type processed at 40˚C, but there were no significant differences between heat cure acrylic and cold cure (both types) processed at high temperatures.

Key words: Resin denture base Materials, hardness, temperature.

Introduction

The strength properties of the self-cured acrylic resin is lower than that of the heat cured type due to lower degree of polymerization of the self-cured acrylic resin with high residual monomer which act as a plasticizer and lower its strength properties[1], this higher residual monomer in the cold cured type, adversely affects the indentation hardness[2,3]. Therefore, the higher conversion of monomer into the polymer results in increasing the hardness of acrylic materials[4].

Cold-cured acrylic resin is basically the same as the heat cured acrylic resin denture base material, varying only in the manner in which polymerization is initiated at room temperature. The composition of the liquid is varied by the addition of chemical activator in the form of tertiaryamine[5].

The wide use of cold-cured acrylic resin in prosthetic work is mainly related to its simple technique at room temperature, less time consuming and less equipment require [6].

Cold-cured acrylic resin is one of the most frequently used materials in dentistry for repairs, relines, orthodontic appliances, maxillofacial prosthesis in addition to its use in crown and bridge work as a temporary coverage of prepared tooth [7,8,9,10]. The increase in processing temperature under pressure during polymerization of acrylic materials result in a more complete polymerization reaction and thus producing a harder polymer network [11,12,13,14] . So this study was conducted to study the effect of increasing temperature on the hardness of two commercially available cold cure acrylic resin materials in comparison to heat cure acrylic and to those processed conventionally at air bench.

Materials and Methods

Table (1) show materials used in the study.

-Preparation of mould: 90 specimens from rectangular shaped metal pattern were prepared. 10 specimens from heat cure resin(major type) .40 specimens from cold cure acrylic(Holland type) and 40 specimens from cold cure acrylic(Germany type) were prepared with dimension of (12mm,6mm,3mm) length, width and depth respectively .

-Methods: The conventional flasking, packing procedures were followed in the preparation of the specimens.

-Curing : 10 specimens from heat cure resin (major type) curing by water bath(short cycle). 20 specimens(10 from cold cure acrylic(Holland type) and 10 specimens from cold cure acrylic(Germany type) cured processed in air, bench curing method, for two hours at 23˚C±5˚C under (20 bar) pressure [15] (control group).

60 specimens(30 from cold cure acrylic(Holland type) and 30 specimens from cold cure acrylic(Germany type)were polymerized by Ivomat In case of using Ivomat ,flask with acrylic resin dough were transferred for curing in the Ivomat curing device containing water under air pressure 30 Pascal for 15 minutes (ADAS, No. 12, 1975) [16],at different temperature (40˚C, 60˚C, and 80˚C)10 specimens for each groups.

After completion and curing the acrylic specimens were removed carefully from the stone mold. All the acrylic resin specimens were finished and polished according to conventional procedure till glossy surface was obtained. The final measurements were obtained using the micrometer and vernier.

Distribution of the sample:

1- Heat cure:10 specimens from heat resin denture base material (major

type) curing by water bath(short cycle)

2-Group H(Holland type) cold resin denture base material

*Group H control: 10 specimens from cold resin denture base material (Holland) curing at air bench.

*Group H1: 10 specimens from cold resin denture base material (Holland) curing at40˚C by ivomate.

*Group H2: 10 specimens from cold resin denture base material (Holland) curing at60˚C by ivomate.

*Group H3: 10 specimens from cold resin denture base material (Holland) curing at80˚C by ivomate.

3-Group G (Germany type) cold resin denture base material

*Group G control: 10 specimens from cold resin denture base material (Germany) curing at air bench.

*Group G1: 10 specimens from cold resin denture base material (Germany) curing at40˚C by ivomate.

*Group G2: 10 specimens from cold resin denture base material (Germany) curing at60˚C by ivomate.

*Group G3: 10 specimens from cold resin denture base material (Germany) curing at80˚C by ivomate.

Methods of evaluation

Shore ((D)) hardness tester was used in this study for measuring the indentation hardness of the specimens(adigital model) for measuring the indentation hardness ,hand held portable hardness tester (made in china)the test load was set to 50 Newton for shore ((D))which is suitable for acrylic resin material ,have sharp point penetrator for testing hard material such as acrylic.

The contact surface of the shore hardness tester must be parallel to the specimen support of the test stand to prevent errors in measurements.

The distance between the specimen surface and the indenter of the hardness tester was set to be 5-12 mm. During carrying out the test the contact period between the specimen and the indenter was 6 seconds. After that the measurements were taken directly from the scale reading. Five measurements were done on different area of each specimen and the average of five readings was calculated.

Results

Table (2) show the descriptive of groups: mean, S.D, min, max values of the hardness of all eight groups.

Heat cure acrylic show the maximum value of hardness(88.8) followed by Group G3 cold cured acrylic Germany type (polymerized by elevated temperature 80˚C) then by group H2 cold cured acrylic Holland type polymerized at 60˚C(88.471).

While group G control Germany type (polymerized at air bench) recorded the minimum value of hardness(81.83). All groups that polymerized at high temperature: 40˚C, 60˚C, and 80˚C show the higher value of hardness in comparison to those processed by conventional methods(at air bench).

Figure 1 show the bar chart that showing the mean of the hardness for the nine groups. Table (3) show the ANOVA test between groups(Holland, Germany, heat cure), there were highly significant differences $P<0.01$ between:

1- Group H(Holland){ H 1, H 2, H 3, control H}.

2- Group G (Germany){ G 1, G 2, G 3, control G }.

3- Group H (Holland) , Group G (Germany) and heat cure.

Table (4) show the LSD between Groups H(Holland) , there were highly significant differences P<0.01 between: H1 & H2 , H1 & H3 , H2&Control and H3&Control, and there was only significant differences P<0.05 between H1&Control , but there was non significant differences P>0.05 between H2 & H3.

Table (5) show the LSD between Group G (Germany) , there were highly significant differences P<0.01 between :G1,G2,G3&Control , and there was only significant differences P<0.05 between G1 & G3 , but there was no significant differences P>0.05 between G1 & G2 , G2 & G3.

Table (6) show LSD between Group H(Holland) and Group G(Germany)there were highly significant differences P<0.01 between:

1-GroupH1 with Groups: G1, G2, G3.
2-control H with Groups: G1, G2, G3 .
3-Group G control with H2, H3.

While there were significant differences P<0.05 between: H1&G Control, and H3&G3,but there were no significant differences P>0.05 between
1-Group H2 with Groups: G1, G2, G3.
2-Group H3 with Groups G1and G2 .
3-Group H Control& Group G Control.

Table(7) LSD of Group H(Holland) , Group G(Germany) and Heat cure denture base material there were highly significant differences P<0.01 between: Heat cure& controls group{that processed by conventional method(H control , G control)}and with H1(Holland curing at 40˚C) ,but there were no significant differences P>0.05 between Heat cure both types of cold cure curing at high temperature (H2, H3, G1, G2, G3).

Discussion

The result show that the all groups of both types of cold cure acrylic (Holland and Germany) that polymerized at high temperature: 40˚C, 60˚C, and 80˚C show the higher value of hardness in comparison to those processed by conventional methods(at air bench, control group)with significant and highly significant differences between them, Also the result showed that cold cured acrylic type Germany (polymerized by elevated temperature 80˚C) show the maximum value of hardness among cold cure groups, in addition to that there were highly significant differences between: group A1and group B1 that processed at 40˚C with groups that processed with higher temperature(60˚C, and 80˚C), so the hardness increase when the temperature of processing increase , the high value of hardness may be related to the more complete polymerization reaction and higher conversion of monomer into polymer thus producing harder polymer network and high molecular weight with long polymer chain length [11,17],also the other probable explanation of the highly significance increasing of hardness in groups polymerized at high temperature can be related to the low amount of water sorption, and vice versa, the highly significance reduction of hardness in groups polymerized at low temperature can be related to the high amount of water sorption , the material with high water sorption have greater decrease in the hardness resistance this finding is confirmed byBahrani et al [13] ,Ogawa et al[18] ,Stafford and smith [19]and Al- Naimi[20] . In that water sorption adversely affects the hardness resistance of acrylic materials, since the water increase the distance between the molecular chains [21] .

While both control groups of cold cure acrylic Germany type and Holland type (polymerized at air bench)

recorded the minimum value of hardness, the explanation of the reduction of the hardness value in the specimens that polymerized at air bench in addition to high amount of water sorption, might be related to the presence of porosity leading to decrease in the hardness because porosity decrease the hardness [7,11] and this result agree with Al-Kafaji[5] , Kassim et al[12] and Al- Naimi [20] .

Studies need to study the effect of increasing time and pressure of curing on the hardness of cold cure acrylic material, also study the effect of increasing temperature on the other properties of cold cure acrylic material.

Conclusion from this study ,the hardness of cold cure acrylic material improved by increasing the temperature of polymerization .All groups of cold cure acrylic materials that polymerized at high temperature: 40°C, 60°C, and 80°C show the higher value of hardness in comparison to those processed by conventional methods (at air bench at 23°C ± 5°C) with significant and highly significant differences. There were highly significant differences between heat cure acrylic and cold cure (both types) processed by conventional methods ,but there were no significant differences between heat cure acrylic and cold cure (both types) processed at high temperatures.

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Table (1): Materials used in the study.

Type of material	Manufacturer	Trade name	Batch number
Pink cold-cure acrylic resin	1-Holand 2-Germany	1- Vertex 2- PAN	1-YG4341 PG3 2-Class 1ISO W
Dental stone	Zhermack SPA-45021 Badia Polesine Italy	Elite Stone	Quality registed ISO 9002
Separating medium	Switzerlada	PD pink colour 1Ib separating film	Produits dentaires S.A 807317
Polythene separating sheets	England	Amalgamated "Trevalon"	Dental trade distribution
Pumice	U.S.A	Grade CL125 fine	Corporation 361, Louisville, Kentucky 40217
Distilled water	Iraq	Al-Mansore com.	----

Table (2) Descriptive of groups

	Group H (Holland)				**Group G (Germany)**				**Heat cure**
	H1 40˚C	**H2 60˚C**	**H3 80˚C**	**H control**	**G1 40˚C**	**G2 60˚C**	**G3 80˚C**	**G control**	
Mean	86.138	88.471	88.394	83.832	88.332	88.43	88.696	81.83	88.8
SD	0.3879	0.5022	0.4008	2.4808	0.3849	0.687	0.2476	2.8610	0.34960
Min	85.66	87.66	87.33	79.33	88	87.33	88.00	76.66	88.00
Max	86.66	89	88.66	86	89	89	89	84	89

Table (3) ANOVA test between groups

` Groups	**F-test**	**P-value**	**Sig**
Group H(Holland)	28.87	P<0.01	HS
Group B (Germany)	50.08	P<0.01	HS
Group H(Holland), Group G(Germany)and heat cure	35.11	P<0.01	HS

*P>0.05 Non significant
**P<0.05 significant
***P<0.01high significant

Table (4) LSD of Group H(Holland)

Groups	Mean difference	P-value	Sig
H1 & H 2	-2.33	P<0.01	HS
H 1 & H 3	-2.256	P<0.01	HS
H 2 & H 3	0.077	P>0.05	NS
H1&Control	2.306	P<0.05	S
H2&Contro	4.639	P<0.01	HS
H3&Control	4.562	P<0.01	HS

*P>0.05 Non significant

Table (5) LSD of Group G (Germany

Groups	Mean difference	P-value	Sig
G 1 & G 2	-0.098	P>0.05	NS
G 1 & G 3	-0.364	P<0.05	S
G 2 & G 3	-0.266	P>0.05	NS
G1&Control	6.502	P<0.01	HS
G2&Control	6.6	P<0.01	HS
G3&Control	6.866	P<0.01	HS

*P>0.05 Non significant

Table (6) LSD of Group H(Holland) & Group G (Germany)

Groups	Mean difference	P-value	Sig
H1,G1	-2.194	P<0.01	HS
H1,G2	-2.292	P<0.01	HS
H1,G3	-2.558	P<0.01	HS
H1&G Control	4.308	P<0.05	S
H2,G1	0.139	P>0.05	NS
H2, G2	0.041	P>0.05	NS
H2,G3	-0.225	P>0.05	NS
H2&G Control	6.641	P<0.01	HS
H3,G1	0.062	P>0.05	NS
H3,G2	-0.036	P>0.05	NS
H3,G3	-0.302	P<0.05	S
H3&G Control	6.564	P<0.01	HS
H Control&G1	-4.5	P<0.01	HS
H Control&G2	-4.598	P<0.01	HS
H Control&G3	-4.684	P<0.01	HS
H Control & G Control	2.002	P>0.05	NS

*P<0.05 Significant
**P>0.05 Non significant
***P<0.01 High significant

Table (7) LSD of Group H (Holland), Group G (Germany) and Heat cure denture base material

Groups	Mean difference	P-value	Sig
Heat cure& H1	2.662	P<0.01	HS
Heat cure&H2	0.329	P>0.05	NS
Heat cure&H3	0.406	P>0.05	NS
H control &Heat cure	4.968	P<0.01	HS
Heat cure&G1	0.468	P>0.05	NS
Heat cure&G2	0.37	P>0.05	NS
Heat cure&G3	0.104	P>0.05	NS
G control & Heat cure	6.97	P<0.01	HS

**P>0.05 Non significant
***P<0.01 High significant

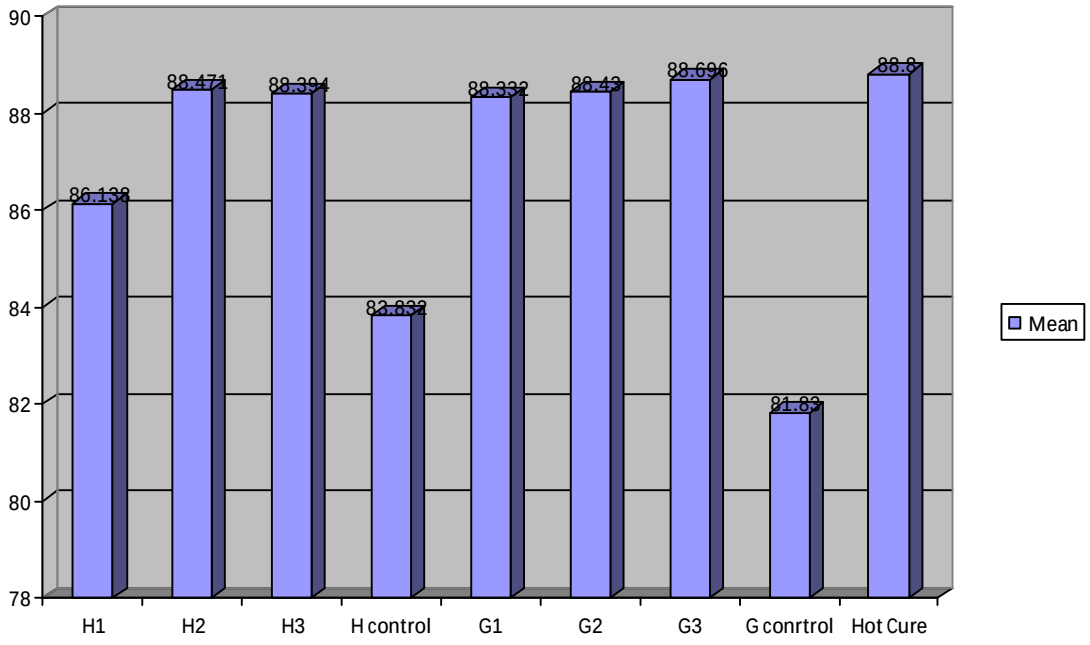

Figure (1) Bar chart showing the mean of the hardness for the nine groups.