The Effect of Different Curing Time on the Impact Strength of Cold and Hot-Cure Acrylic Resin Denture Base Material

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Abstract

Objectives: This study aims to establish the effect of different curing times.
on the impact strength of cold- cure acrylic resin which cured in air and Ivomat curing machine then compare them with heat cure acrylic resin samples which cured in compression molding technique .

Methodology : Eighty acrylic resin specimens were prepared (40 cold cure and 40 heat cure), the study contain 8 groups depending on the type of the processing method and processing time , (10 specimens) were used for each test group, then evaluate the effect of them on the impact strength of acrylic resin denture base material.

Results: The result obtained in the present study showed significant difference between most of the tested groups. However the tested group that cured in 70°C for 9 hours showed the highest impact strength mean value in regarding to heat cure acrylic resin .While the test group which cured in Ivomat curing machine for 45minut showed the highest impact strength mean value in regarding cold cure acrylic resin

Conclusion: It can be concluded that heat- cure acrylic resin had better impact strength than cold- cure acrylic resin , and the curing time had a significant effect on the impact strength of both heat and cold – cure acrylic resin .

الخلاصة

الأهداف دراسةِ تأثير استخدام أوقاتِ مختلفة على قوة الصدمة للاكريل الراتنجي ا لمُعَالَجَ ذاتيا(في الهواء وجهاز الايفوميت) ومقارنة النتائج مع عينات الاكريل الراتنجي المعالج حراريا بأستخدام طريقة ضغط القالب وبأوقات معالجة مختلفة أيضا.

تم تهيئة ثمانون عينة من الراتنجِ ألاكريلي (٤٠ عينة من الاكريل البارد و٤٠ عينة من الاكريل الحار)، تَحتوي الدراسةَ على ٨ مجاميع اختبارية إعتِمادا على نوعِ طريقةِ المعالجة ووقتِ المعالجة ، تم استخدام ١٠ عيناتَ لكُلّ مجموعة إختباريةِ. وتْمّ تقييمُ تأثيرَ كل منهم على قوّةِ صدمة الراتنجِ ألاكريلي البارد والحار.

اظهرت النتائج في هذه الدراسةِ وجود اختلافات معنوية ملحوظة إحصائيا بين أغلب المجموعاتِ الاختباريةِ. سجلت النتائج اعلى قيمة لمعدل قوة الصدمة في عينات الاكريل الراتنجي المعالج حراريا في(٧٠ درجة سليزية لمدة ٩ ساعات) , بينما سجلت أعلى قيمة لمعدل قوة الصدمة في عينات الاكريل الراتنجي المعالج ذاتيا في (جهاز الايفوميت لمدة ٤٥ دقيقة). وهناك تأثير ملحوظ احصائيا للوقت المستخدم في المعالجة على قوة صدمة الاكريل الراتنجي البارد والحار.

Introduction

The most commonly used material for the construction of denture is Poly (methyl methacrylate). However this material is still far from ideal and, because of its relatively low mechanical strength, fracture of denture is an unresolved problem. Over the years several attempts have been made to

improve the mechanical properties of acrylic resin [1-6].

Self- cured acrylic resin is one of the most frequently used material 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[7,10]. The wide use of Self- cured acrylic resin in prosthetic work is mainly related to its simple technique at room temperature, less time consuming and less equipment required[11]. While the strength properties of self- cured resin is lower than that of heat- cured type due to lower degree of polymerization of self- cured resin with high residual monomer which act as a plasticizer and lower its strength properties[12]. Several studies were done where the effect of heat, pressure and time on polymerization reaction and strength of the Self- cured acrylic resin were examined[13].

This study is conducted to test the effect of different curing time on the impact strength which is a measure of energy absorbed by material when it is broken by a sudden blow [14-16] of the self and heat - cured acrylic resin and compare between the result of them in order to identify the best curing time that improve the impact strength of the self and heat - cured acrylic resin.

Materials and Methods

Eighty specimens were prepared from pink cold (Major 2- Italy) and heat (Major Base 2- Italy) - cure acrylic resin by using rectangular-shaped metal (iron) pattern which constructed with dimensions (65.5mm X 12.7mm X 3.75mm) length, width, and depth respectively according to ADA specification no. 12 (1999) for denture base polymer for impact strength test[5]. The study includes two main groups of specimens depending on the type of acrylic resin used ,each of them subdivided into four groups according to the time used during curing procedure which include in air for 15 minutes (Group A1) and in Ivomat (15 minutes(Group A2) , 30 minutes(Group A3) and 45 minutes(Group A4).Whereas for heat cure groups include 100°C for 45 minutes(Group B1), 70°C for 7 hours(Group B2), 70°C for 9 hours(Group B3) and 100°C for 1 hours (Group B4) as shown in Figure (1).

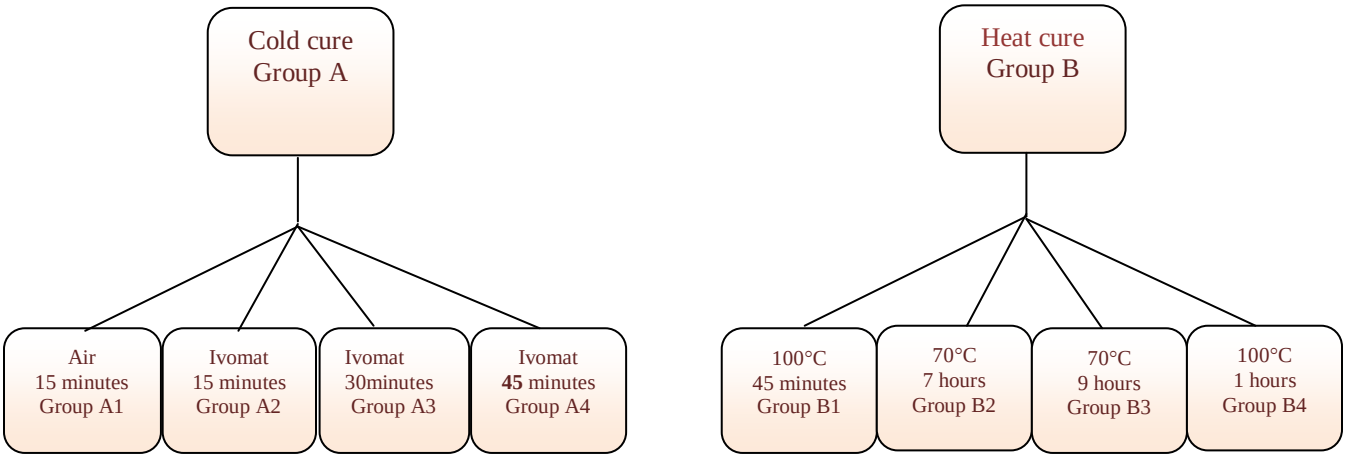

Figure 1 Diagram illustrates specimens groping

Curing:

The flasks which used to prepare specimens for the first group (Group A1) were kept to cure in air for two hours in a bench under press at23°C ± 5°C. The flasks that used to prepare group (A2,A3,A4) were transferred for curing in the ivomat curing device at 50°C under air pressure 30 psi [13] for different curing time (15 minutes, 30 minutes and 45 minutes). While in case of preparing the second group of samples flasks (Group B) they cured by keeping the flasks in the water in the curing equipment having a thermostat and time controller. For the (Group B1) specimens the cycle started by immersion flasks in water at room temperature and then raising water temperature gradually to reach boiling and maintained at this for(45 minutes). The specimens in (Group B2) were cured by immersing the flasks in water bath at ambient temperature and raising the water temperature gradually to (70 °C) and maintained at this for (7 hours). The specimens in (Group B3) were cured by immersing the flasks in the water bath at ambient temperature and gradually raising the water temperature to reach (70 ºC) and then maintaining at this temperature for (9 hours). The specimens in (Group B4) were cured by immersing the flasks in water at ambient and raising the temperature of water to reach(100 0C) and maintained for (1 hour) [17]. After completing the curing, the flask was allowed to cool slowly at room temperature for 30 minutes. All the acrylic resin specimens were finished and polished and the final measurements were obtained as shown in figure (2).

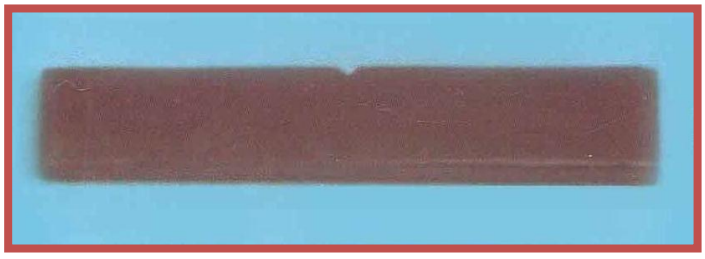

Figure 2 Impact strength acrylic sample

Testing Procedures:

Impact test was done by IZOD type impact machine (ASTM) D256-85 to measure impact strength of acrylic resin specimens as shown in figure (3). The device was supplied with a pendulum which could produce different weights according to the materials to be tested. The specimens were held vertically at one end, and struck by the pendulum of (2J) capacity at the center of the tested specimen in the notch area. The scale reading gives the impact energy in (dj). The values of Izod impact strength were computed by the following formula (According to ISO 180 (2000) for determination of impact strength.[18]

$$\text{Impact strength}(J/m) = \frac{E}{hb}$$

Where E is the absorbed energy in (J), while h is the thickness of the specimen and b is the remaining width at the notch base in (m).

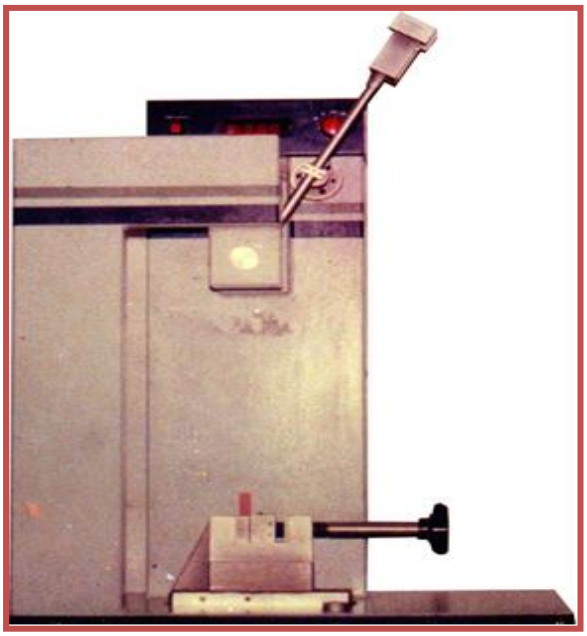

Figure 3 IZOD type impact machine

Statistic methods used to analyze and assess the result study were :
1- Descriptive statistic .
A- Mathematic mean . B- Standard deviation. C-Standard Error
2- ANOVA table with the result of multiple comparison test (LSD).

Results

The results show that the Impact strength values for cold and heat–cure acrylic resin specimens vary with the method and time used during curing procedure. The highest mean impact strength values specimens were obtained in heat-cure acrylic resin cured in (70°C for 9 hours)(group B4) which was (25.000 J/m), and their lowest mean impact strength value of were obtained in cold-cure acrylic resin cured in (air) (group A1) which was (12.109 J/m), as shown in Table (1) .

Table 1 Descriptive statistics for Impact strength of cold and heat-cure acrylic resin cured at different curing time and process.

Cold-cure acrylic resin (group A)	**Mean**	**SD**	**SE**
(group A1)Air	12.507	0.431	0.14
(group A2)15 minutes	13.841	0.563	0.18
(group A3) 30 minutes	15.477	0.597	0.19
(group A4)45 minutes	16.982	0.606	0.21
Heat-cure acrylic resin (group B)			
(group B1)100°C for 45 minutes	20.492	0.631	0.20
(group B2)70°C for 7 hours	24.994	0.360	0.11
(group B3)70°C for 9 hours	27.056	0.599	0.19
(group B4)100°C for 1 hours	21.02	1.12	0.35

One way ANOVA with LSD of multiple comparison test, showed that there was a significant difference at ($P<0.05$) between most of the tested groups, except for a non significant difference at ($P>0.05$) between heat-cure acrylic resin specimens cured in (100°C for 45 minutes)(group B1) and those cured in (100°C for 1 hours)(group B4) as shown in Table (2).

Table 2 Least significant difference (LSD)

Acrylic resin		Cold-cure				Heat-cure			
		GroupA 1	GroupA 2	GroupA 3	GroupA 4	GroupB 1	GroupB 2	GroupB 3	GroupB 4
Cold-cure	GroupA1		S	S*	S*	S*	S*	S*	S*
	GroupA2			S	S*	S*	S*	S*	S*
	GroupA3				S	S*	S*	S*	S*
	GroupA4					S*	S*	S*	S*
Heat-cure	GroupB1						S*	S*	N.S
	GroupB2							S*	S*
	GroupB3								S*
	GroupB4								

N.S =Non Significant P value >0.05, S= Significant P value <0.05, ⋆=High Significant

Discussion

Heat cure acrylic specimens in general showed more increase in impact strength than cold-cure acrylic specimens, this due to the fact that heat cured acrylic is less porous than cold-cured acrylic, which could lower the impact strength. This was in agreement with Robinson and McCabe[19] they found that porosity could cause a reduction in the force required to break the sample by forming a path of fracture.

The significant improvement of impact strength in cold-cure acrylic specimens cured in Ivomat curing machine for (30 and 45 minutes) due to the point that presence of sufficient time during curing procedure that could produce more complete polymerization with less chance of residual monomer which may be responsible for increasing the impact strength. This in agreement with Mohammed[20].While the improvement of impact strength in heat-cure acrylic specimens cured in at (70°C for 7 hours) and (70°C for 9 hours) this outstanding to the circumstance that a slow polymerization cycle create lowest residual monomer concentration which increases impact strength, this agree with Yau et al and Mohammed [21,22].The other explanation perhaps associated to the less porosity in specimens processed by curing in hot water and adequate time during curing procedure this agree with AL-Berqdar et al and Ghani et al [21,22].

Conclusion

From the result in this present study it can be concluded that the best curing time for cold cure acrylic specimens was in Ivomat for 45 minutes that showed significant improvement in impact strength. While the most excellent curing time for heat-cure acrylic specimens was70°C for 9 hours which showed the highest impact strength.

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