Evaluation of shear bond strength of artificial teeth to heat cure acrylic and high impact heat cure acrylic using autoclave processing method

Mustafa M.J., B.D.S., M.Sc. [(1)]

ABSTRACT

Background: Debonding and fracture of artificial teeth from denture bases are common clinical problem, bonding of artificial teeth to heat cure acrylic and high impact heat cure acrylic denture base materials with autoclave processing method is not well known. The aim of this study was to evaluate the effect of autoclave processing method on shear bond of artificial teeth to heat cure denture base material and high impact heat cure denture base material.

Materials and methods: Heat polymerized (Vertex) and high impact acrylic (Vertex) acrylic resins were used. Teeth were processed to each of the denture base materials after the application of different surface treatments. The sample (which consist of artificial tooth attached to the denture base at 45 degree) are consist of (80) artificial teeth from the same model of central incisor, they were prepared , treated and bonded to the conventional heat cured and high impact acrylic denture base material then processed.

Control group (Group A 40 samples) in which acrylic resins PMMA cured by conventional water- bath processing technique (74°C for 1.5 hours then boil for 30 minutes),the group was subdivided to 20 samples heat cure acrylic and 20 samples high impact acrylic.

Experimentalgroups (Group B 40 samples) in which acrylic resins was cured by autoclave at 121°C, 210KPa. For 30min.the group subdivided to 20 samples heat cure acrylic and 20 samples high impact acrylic.

For each subgroup, the 20 samples were subdivided according to surface treatment into:

1-Five acrylic teeth without any surface treatment (control).

2- Five acrylic teeth with diatoric preparation (retention grooves).

3- Five acrylic teeth conditioned with thinner.

4- Five acrylic teeth with retention grooves and thinner.

Results: Statistical analysis revealed that chemical and mechanical treatment of acrylic teeth improved the shear bond with heat cure and high impact acrylicalsoautoclave processing improvedthe shear bond with acrylic teeth in high impact acrylic.

Conclusion: Autoclave polymerization is suggested as alternative method for processing denture base resins. Autoclave polymerization can be easily performed in laboratory conditions. In High Impact Acrylic, there were highly significant differences of autoclave processing technique compared with water bath regarding the shear bond strength with acrylic teeth.

Key words: High impact acrylic resin, autoclave polymerization, artificial teeth, deboning. (J Bagh Coll Dentistry 2014; 26(4):71-77).

الخلاصة

الخلفية:خلع وكسر الأسنان الاصطناعية من قواعد أسنان هي من مشاكل الطقم الشائعة، الترابط بين الأسنان الاصطناعية وقاعدة الطقم بطريقة تسخين الاكريليك مع طريقة معالجة الأوتوكلاف ليست معروفة جيدا، وكان الهدف من هذه الدراسة تقييم تأثير طريقة معالجة الأوتوكلاف على ارتباط الاسنان الاصطناعية مع قاعدة طقم الاسنان .

المواد و الاساليب:تم استعمال الاكريلك الحراري والاكرلك المقاوم للصدمات كمادة لقاعدة الطقم وتم لصق الاسنان لكل نوع من انواع الاكرلك بعد المعالجة السطحية تتكون العينات من ثمانين عينة نفس النوع والطراز من السن القاطع الامامي العلوي تم تحضير الاسنان ومعالجتها لكل نوع من انواع قاعدة الطقم ,المجموعة الرئيسية تتكون من اربعين عينة مرتبطة بالاكرلك الحراري مطبوخة بطريقة البلمرة المائية ومقسمة الى عشرين عينة مطبوخة بطريقة البلمرة المائية (74) درجة سليزية لمدة(1.5) ساعة وبعد ذلك غليان لمدة 30 دقيقة هذه المجموعة مقسمة الى 20 عينة اكرلك حراري و20 عينة مقاوم للصدمات .المجموعة المختبرية تتكون من اربعين عينة مرتبطة بالاكرلك الحراري ومبلمرة بطريقة الاوتوكليف وبنفس التقسيمات بالمجموعة الاولى .

قسمت العينات تبعاً لطريقة المعاملة السطحية على :

1- خمسة عينات بدون معاملة سطحية .
2- خمسة عينات معاملة ميكانيكية بطريقة الاخاديد السطحية .
3- خمسة عينات معاملة كيميائية بمادة الثنر .
4- خمسة عينات معاملة ميكانيكياً وكيميائياً .

الاستنتاج:مع محدودية البحث يستنتج بأن طريقة الاوتوكليف للبلمرة من الممكن اعتبارها الطريقة البديلة بطريقة البلمرة المائية او الطبخ المائي وفي الاكرلك المقاوم للصدمات لوحظ وجود زيادة واضحة احصائياً لطريقة الاوتوكليف مقارنتاً بطريقة البلمرة بالطبخ المائي في ما يخص الارتباط القصي السطحي مع الاسنان الصناعية .

INTRODUCTION

Poly (methyl methacrylate) (PMMA) or heat cured acrylic is the most commonly used material in construction of denture base since 1936 [(1)]. This material is not ideal for using in every case, and it is a combination of different rather than one single desirable property that account for its wide usage.

Despite its popularity in satisfying aesthetic, simple processing and easy repair, it is still far from ideal in fulfilling the mechanical requirements of prosthesis [(2)]. The vast majority of dentures made today are fabricated from heat cured Poly (methyl methacrylate) and rubber-

(1)Assistant Lecturer. Department of Prosthodontics, College of Dentistry, University of Baghdad

reinforced poly (methyl methacrylate) [3]. High-impact strength acrylics employ a PMMA polymer modified by adding a rubber compound to improve strength properties [4].

Over the years, curing procedures have been modified with a view to improve the physical and mechanical properties of resin materials. Different polymerization methods have used: heat, light, chemical and microwave energy [5,6].

Indian researchers investigated the pressure cooker polymerization technique; Conventional PMMA material can be used for this technique and requires less than 1h for polymerization and used conventional equipment used for heat cure processing. Previous studies of pressure cooker polymerization showed comparable physical and mechanical properties to the water bath technique [7].

The failure rate of acrylic resin dentures due to fractures have been reported to be an acceptably high and the most common type of failure encountered was de-bonding fracture of the teeth [5,8]. Previous researches have indicated that chemical or mechanical preparations or modifications of the denture teeth surface of artificial teeth prior to bonding improved bond strength [9,10].

There is no previous Iraqi study that investigated the effect of autoclave processing or curing method on shear bond of artificial teeth to different types of heat cure denture base material. Therefore, the aim of this study was to investigate the effect of autoclave processing method on shear bond of artificial teeth to heat cure denture base material and high impact heat cure denture base material.

MATERIALS AND METHODS

Materials

Table 1 showed some of the materials used in this research

Table 1. Some of materials that were used in this study

	Materials	Manufacturer
1.	Heat cured acrylic resin (powder and liquid	Vertex,Holland
2.	Heat-curing, High impact resin for denture (powder+liquid)	Vertex,Holland
3.	Extra hard type IV dental stone	Zhermak , Italy
4.	Separating medium	Isodent,Spofa Dental Czechoslovakian Europe
5.	Distilled water	Iraq
6	Artificial teeth	Acrylic, Floridient
7	Thinner	Dyna- Coat Thinner Standar Netherlands

Conventional artificial teeth (acrylic, Floridient) were chosen to be bonded to two types of denture bases: (group A heat cure, and group B high impact denture bases), total of 80 acrylic teeth 40 teeth for each group (20 teeth for heat cure (conventional cure) and 20 teeth for autoclave cure), each subgroup contained:

1-Five acrylic teeth with out any surface treatment (control).

2- Five acrylic teeth with diatoric preparation (retention grooves).

3- Five acrylic teeth conditioned with thinner.

4- Five acrylic teeth with retention grooves and thinner.

All denture teeth were maxillary central incisors. For each denture base, the teeth were waxed onto the beveled surface of a rectangular wax block (Figure 1).

The slope of the beveled surface aligned each artificial tooth such that the long axis of the tooth was at 45 degrees from the base of the wax block as shown in figure 2.

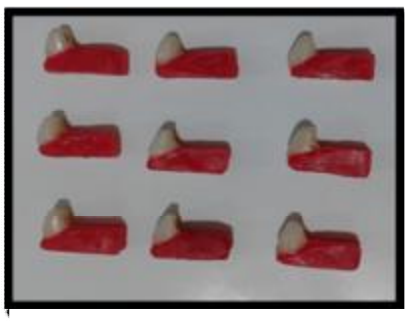

Figure 1: Acrylic teeth attached to waxed blocks.

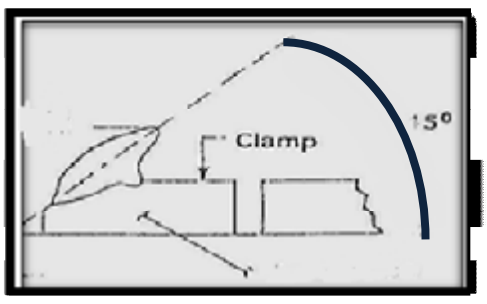

Figure 2: The configuration of the specimen (JIST6506 1989)

The denture teeth were flasked and the wax was eliminated with running hot water. The ridge lap surfaces of the artificial teeth were treated with chemical solvent (thinner for acrylic teeth) or were prepared by diatoric or a combination of both or with no surface treatment. The diatoric was prepared by cutting a groove (2mm width and 3mm depth) mesio-distally drilled into the ridge lap surface of each artificial tooth with an inverted cone bur. The artificial teeth that did not undergo any surface treatment were used as controls.No.0 brush was used for painting the teeth surfaces with thinner at room temperature for three minutes [(11)].

For both heat cured acrylic and high impact acrylic, the denture resins were packed in flask for heat processed by conventional water- bath processing technique (74°C for 1.5 hours then boil for 30 minutes) and experimental groups (Group B 40 samples) in which acrylic resins were processed by autoclave at 121°C, 210KPa for 30min., then they were tested . Shear load was applied at 45 degrees from the long axis of each denture tooth on the palatal surface at a cross head speed of 1.5mm/min with 20 KN load until fracture. The shear bond strength was calculated based on the force (F) in (N) at fracture and adhesive surface area (S) in (mm^2) and converted to (Mpa).

[[B.S= F/S]]

B.S= Bond Strength (N/mm^2) or (Mpa).

F= Force at failure (N).

S= Surface area of cross section in (mm^2) and this was calculated automatically by the program of the Instron machine [(12)] (figure 3).

$S= (\pi / 4) * D^2$

π= 22/7 or 3.14

D (diameter) = 5 mm.

S= 19.64 mm^2

Specimen attached to metal fixture fixed on the Instron machine immediately to avoid the stress relaxation and subjected to shear stress until failure [(13)].

Figure 3: Instron machine with tooth clamp

Statistical analyses

The data were subjected to computerized analysis using SPSS program version 21. The statistical analyses included; descriptive statistics (means, standard deviations, minimum and maximum values and statistical tables), while One-way ANOVA test for comparison among the groups then LSD test if ANOVA showed significant difference and t test

RESULTS

Descriptive statistic showed that for heat cure acrylic samples, the lowest mean value for the shear bond was for that specimens processed by water bath and autoclave processing for the subgroup of samples without surface treatment (control group), and the highest value for the group that undergo mechanical and chemical treatment, the same result were seen in the high impact acrylic samples for both processing methods (table1).

Table 1: Descriptive statistics

Types of acrylic	Types of processing		N	Mean	S.D.	Min.	Max.
Heat cure	Water bath	1	5	8.636	0.30	8.30	9.01
		2	5	9.38	0.36	8.91	9.72
		3	5	9.20	0.35	8.70	9.62
		4	5	14.28	0.70	13.24	15.17
	Autoclave	1	5	8.64	0.17	8.45	8.91
		2	5	9.69	0.40	9.06	10.13
		3	5	9.25	0.28	8.91	9.62
		4	5	14.25	0.46	13.64	14.74
High impact	Water bath	1	5	7.90	0.27	7.50	8.20
		2	5	9.85	0.51	9.11	10.43
		3	5	9.32	0.76	8.14	10.18
		4	5	13.92	0.69	12.78	14.56
	Autoclave	1	5	8.56	0.24	8.30	8.91
		2	5	10.70	0.38	10.23	11.25
		3	5	7.93	0.36	7.53	8.40
		4	5	14.55	0.30	14.20	14.86

The One way ANOVA revealed highly significant difference in high impact acrylic processed by autoclave method (P<0.001) with significant difference in heat cured acrylic processed by the two methods also there were high significant differences in the artificial teeth surface treatments and denture base interactions (P<0.001) (Tables 2 and 3).

Table 2: Comparison among groups in each type of processing in different surface treatment

Types of acrylic	Types of processing	ANOVA	Sum of Squares	df	Mean Square	F-test	p-value
Heat cure	Water bath	Between Groups	103.424	3	34.475	166.308	0.000 (HS)
		Within Groups	3.317	16	0.207		
		Total	106.741	19			
	Autoclave	Between Groups	98.476	3	32.825	270.781	0.000 (HS)
		Within Groups	1.940	16	0.121		
		Total	100.416	19			
High impact	Water bath	Between Groups	99.976	3	33.325	95.367	0.000 (HS)
		Within Groups	5.591	16	0.349		
		Total	105.567	19			
	Autoclave	Between Groups	133.813	3	44.604	417.312	0.000 (HS)
		Within Groups	1.710	16	0.107		
		Total	135.523	19			

Table 3: LSD test after ANOVA

Types of processing			Heat cure acrylic		High impact acrylic	
			Mean difference	p-value	Mean difference	p-value
Water bath	1	2	-0.740	0.021 (S)	-1.958	0.000 (HS)
		3	-0.564	0.068 (NS)	-1.428	0.002 (HS)
		4	-5.648	0.000 (HS)	-6.020	0.000 (HS)
	2	3	0.176	0.550 (NS)	0.530	0.175 (NS)
		4	-4.908	0.000 (HS)	-4.062	0.000 (HS)
	3	4	-5.084	0.000 (HS)	-4.592	0.000 (HS)
Autoclave	1	2	-1.052	0.000 (HS)	-2.136	0.000 (HS)
		3	-0.612	0.013 (S)	0.634	0.007 (HS)
		4	-5.606	0.000 (HS)	-5.984	0.000 (HS)
	2	3	0.440	0.063 (NS)	2.770	0.000 (HS)
		4	-4.554	0.000 (HS)	-3.848	0.000 (HS)
	3	4	-4.994	0.000 (HS)	-6.618	0.000 (HS)

Effect of curing techniques

t-test of the comparison showed that the high impact acrylic cured by conventional generally possessed significantly higher shear bond strength than the heat cured acrylic in autoclave processing method

Effect of surface treatments

t-test of surface treatments of artificial teeth showed that the acrylic teeth had higher bond strength than the control group teeth (P<0.001). Diatoric preparation significantly improved the bond strength of artificial teeth (P<0.001) (table 4).

The application of thinner to acrylic teeth significantly enhanced the bond strength also the combination of thinner treatment with the diatoric preparation gives the highest bond strength of these teeth to both types of denture base material for both types of processing (table 5).

A. Thinner Wetting:

Thinner wetting improve the S.B.S. significantly high (p≤0.001) in all thinner conditioned acrylic teeth bonded to both control and experimental denture bases (table 5).

Table 4: Comparison between the types of processing for each type of acrylic

Types of acrylic		Types of processing	Descriptive statistics		Processing types comparison		
			Mean	S.D.	t-test	df	p-value
Heat cure	1	Water bath	8.64	0.30	-0.041	8	0.968 (NS)
		Autoclave	8.64	0.17			
	2	Water bath	9.38	0.36	-1.309	8	0.227 (NS)
		Autoclave	9.69	0.40			
	3	Water bath	9.20	0.35	-0.269	8	0.795 (NS)
		Autoclave	9.25	0.28			
	4	Water bath	14.28	0.70	0.097	8	0.925 (NS)
		Autoclave	14.25	0.46			
High impact	1	Water bath	7.90	0.27	-4.064	8	0.004 (HS)
		Autoclave	8.56	0.24			
	2	Water bath	9.85	0.51	-2.944	8	0.019 (S)
		Autoclave	10.70	0.38			
	3	Water bath	9.32	0.76	3.703	8	0.006 (HS)
		Autoclave	7.93	0.36			
	4	Water bath	13.92	0.69	-1.867	8	0.099 (NS)
		Autoclave	14.55	0.30			

Table 5: Comparison between the types of acrylic for each type of processing

Types of processing		Types of acrylic	Descriptive statistics		Acrylic types comparison		
			Mean	S.D.	t-test	df	p-value
Water bath	1	Heat cure	8.636	0.30	4.056	8	0.004 (HS)
		High impact	7.90	0.27			
	2	Heat cure	9.38	0.36	-1.702	8	0.127 (NS)
		High impact	9.85	0.51			
	3	Heat cure	9.20	0.35	-0.330	8	0.750 (NS)
		High impact	9.32	0.76			
	4	Heat cure	14.28	0.70	0.839	8	0.426 (NS)
		High impact	13.92	0.69			
Autoclave	1	Heat cure	8.64	0.17	0.595	8	0.568 (NS)
		High impact	8.56	0.24			
	2	Heat cure	9.69	0.40	-4.022	8	0.004 (HS)
		High impact	10.70	0.38			
	3	Heat cure	9.25	0.28	6.499	8	0.000 (HS)
		High impact	7.93	0.36			
	4	Heat cure	14.25	0.46	-1.212	8	0.260 (NS)
		High impact	14.55	0.30			

DISCUSSION

Effect of surface treatments

The placement of groove significantly improved the bond strength of artificial teeth, the use of thinner for acrylic teeth achieved even higher shear bond strength [14].

The benefit of using diatoric groove may be explained by that, the diatoric provide a wider contact area with denture base resin and greater mechanical retention and, increases the surface area on the artificial teeth available for the polymerizing denture base to interact with. Also, the diatoric of the denture base resin embedded in the artificial tooth creates a path of resistance to fracture in a direction different from the tooth–denture base interface. These mechanically strengthen the bond between the artificial tooth and the denture base [13,15].

A.Thinner wetting

Thinner wetting improved the shear bond strength significantly, these effects were due to that thinner wetting which is a strong solvent since it is chemically composed from multiple solvents could dissolve the polymer that facilitated the diffusion of the polymerizable monomer from the denture base to the surface treated tooth that facilitate the creation of a more interwoven polymer network for both types of acrylic. These findings were similar to those of previous studies like other studies [16,17].

Effect of curing technique

In High Impact Acrylic, The results showed that there was a highly significant difference in shear bond between autoclave and water bath methods. This may be caused by the pressure, that speeding up the initial polymerization and elevating the boiling temperature of the monomer and thus might reduce the residual monomer content [18], too rapid a rise in temperature produces large numbers of radicals and, as a result, many growing polymer chains. These chains collide either with other radicals or with polymer chains, producing an increase in branching and cross-linking of the interstitial polymer [19], no previous study investigated the effect of autoclave processing on the shear bond strength of acrylic teeth to high impact acrylic resins were found to further investigate the effect of autoclave curing on various types of resins, and effect of time and temperature of autoclave curing, more detailed studies should be carried out.

Under the conditions of this study, it could be concluded that autoclave polymerization was a potential alternative method for processing denture base resins. Autoclave polymerization can be easily performed in laboratory conditions. In High Impact Acrylic, there were highly significant differences of autoclave processing technique compared with water bath regarding the shear bond strength with acrylic teeth.

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