



Evaluation of the effect of different surface treatment on the transverse strength of the repaired acrylic denture base resin cured by two different techniques

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Abstract

One of the most important practical deficiencies of present denture base materials is fracture, therefore many attempts have been made to reinforce of the repaired denture base resin, a desirable objective for this service is to obtain optimum strength for repair, which can be achieved by making available a good bound between original and repair materials.

The present study was carried out to evaluate and compare the effect of different surface treatments (monomer, acetone, combination monomer + acetone) on the transverse strength of acrylic denture base.

Seventy (70) specimens were prepared from pink heat-cure acrylic resin of which (10) specimens were considered a control group. The remaining specimens were divided into two main groups (30specimens repaired by Ivomat and 30 specimens repaired by air method).

The joint treated before cold-cured acrylic resin was applied to the joint space. Specimens were repaired by cold-curing resin (major). Then they were stored in distilled water at (37 C°) for (48) hours. These were subjected to three-point loading testing machine to determine the transverse strength.

The results showed that air cured acrylic resin has significant lower transverse strength than Ivomat cured acrylic resin also show that the specimen treated with (Acetone + monomer) have a higher transverse strength.

Finally, it can be concluded that curing methods and surface treatment will improve transverse strength of the repaired acrylic denture base resin.

Introduction

Acrylic resin is an indispensable material in removable prosthodontics. Although, widely used as a denture base material, acrylic resin exhibits poor mechanical properties where fractures may occur either outside or inside the mouth. Denture base acrylic resin is subjected to many different types of stresses, intra orally, Repeated masticatory force leads to fatigue phenomena, while extra orally high-impact forces may occur as a result of dropping the prosthesis. As a

consequence, fracture of the denture base can result, regardless the reason of fracture or the method of repair. The ultimate goal of denture repair is to restore the dentures original strength and avoid further fracture. Satisfactory repair must be easily and rapidly completed, match the original color of material, and maintain dimensional accuracy during repair¹.

Several materials have been used to repair fractured acrylic dentures, including auto polymerized acrylic

resin, Heat-polymerized acrylic resin, visible light-Polymerized resin, and microwave resins. Also several techniques have been proposed to repair fractured denture to restore their original strength, including heat activation, microwave activation, cold cure activation and light cure activation. In essence, the success of denture repair relies on the phenomenon of adhesion^{2, 3, 4, 5}.

Adhesion between denture bases and repair materials can be improved by repair surface designing, repair surface treatments applying appropriate chemical to the acrylic resin surfaces. These chemical etch the surface by changing its morphology and chemical properties, normally this etching is obtained by wetting the surface with a monomer⁶.

The repair surface was treated either with monomer of cold-cure acrylic, monomer of rebaron (chair side relining material) or acetone for different periods of time before repair material placement. The results showed that the repaired specimens without wetting were much weaker than the unrepaired control samples. The strength and deflection of the test specimens increased as the duration of wetting with each chemical solvent increases. The highest strength values with obtained for specimens wetted with acetone for 180 seconds and for specimens wetted with monomer of rebaron.⁷

However, as poly methyl-methacrylate (PMMA) is soluble in organic solvent such as chloroform, acetone, and methylene chloride, these chemicals can also be used as etchers. These surface modifications improve the bond strength of heat acrylic resins to denture base^{8, 9, 10}.

The increase in the temperature of polymerization improves mechanical and chemical properties of acrylic resin. For instance, conventional heat-

polymerized acrylic resins are known to be the strongest materials for denture base fabrication, with the former exhibiting similar or superior transverse strength values than the latter. The repair strength of heat-polymerized materials ranges from (75%-80%) of the original strength of the acrylic¹¹.

In the present study transverse strength of repaired acrylic specimens had been evaluated using different surface treatments and curing methods.

Materials and methods

Materials

The materials used in the present study are:

Materials	Manufactured by
Heat-curing denture base resin/powder and liquid	Iran
cold-curing denture base resin/powder and liquid	Iran
Dental stone	Germany
Separating medium	china
Polythene separating sheets	Turkey
Acetone and Distilled water	Iraq
Pumice	USA

Equipments and Instruments:

These equipments and Instruments were used in this study:

- 1- Metal pattern blocks, holding devices, and mixing vessel.
- 2- Bristle, Fine brushes NO. Zero, and wool brush.
- 3- Watch, lacron carver, wax knife, rubber bowel, and Vernier (Rostfrei, Germany).
- 4- Clamps (Hanau engineering comp. USA), dental metal flask, and hydraulic press (Hydrofix Bego, Germany).
- 5- Finishing burs (acrylic, stone, invested cone and sand paper bur).

- 6- Lathe polishing machine (Bego, Germany), Rag wheel with Gouge, and Sand paper (grit 600, Germany).
- 7- Incubator (Memmert, Germany).
- 8-Prosthetic hand piece (W&H), and Dental vibrator (e-z flo vibrator kerr USA).
- 9- Thermostatically controlled curing unit (Kavo Gmbh West Germany).
- 10- Instron universal testing machine (Instron, corporation\ 195 Canton, Mass).
- 11- Thermometer, and Electronic balance (Sartorius B13100 Germany).

Methods:

Specimens grouping

Seventy (70) specimens were prepared from pink heat-cure acrylic resin denture base for transverse strength test.

Specimens were grouped as following:

Group 1 contain (10) specimens as a control.

Group 2 contain (30) specimens were cured by Air:

- Ten specimens were repaired with Monomer.
- Ten specimens were repaired with Acetone.
- Ten specimens were repaired with Monomer and Acetone.

Group 3 contain (30) specimens were cured by Ivomat:

- Ten specimens were repaired with Monomer.
- Ten specimens were repaired with Acetone.
- Ten specimens were repaired with Monomer and Acetone.

As shown in Figure (1).

General preparation of the Acrylic specimens:

Metal patterns were constructed [65mm x 10mm x (2.5±0.03mm)] length, width, and depth respectively

as shown in Figure (2). According to the ADA specification No.12, 1999.

The lower portion of the dental flask was filled with dental stone mixed according to manufacturer instructions (i.e. 31ml/100gm); a layer of stone mix was place on metal block to avoid trapping of air when inserting the metal block into the stone mix after coating with separating media.

After stone was set, both the stone and pattern were coated with separating media. The upper half of the flask was then positioned on top of lower portion and filled with stone. Stone was allowed to harden for 60 minutes before the flask was opened. The metal pattern was invested each time when the samples are to be prepared. The flask was then opened and metal patterns were removed from the mould carefully.

Then the acrylic resin was prepared according to manufacturer instructions then dough was packed in the mould in the conventional method, all specimens were finished and polished. The specimens were conditioned for one week in distilled water at 37 C according to ADA specification NO.12 (1999) before fracture and repaired.

Preparation of the repaired Acrylic Specimens.

The stone mould which had been used for processing the acrylic specimens was used as an index for these specimens in the repair procedure. The samples and indices were numbered on corresponding ends to allow realignment in the original position.

1- Preparation of the repaired Acrylic Specimens with surface treatment by Solvents.

A. Fracturing and joining preparation.

Metal holding devices were constructed for prepared joint of

fracture. The specimen was prepared by using metal holding device had a central recess (central groove), and the open end of the holding device was 45 degree bevel. The acrylic specimen was placed in the central groove and cut with fissure bur near the bevel end. The other end was put aside during the preparation of the part inside the central recess. The cut end was prepared with acrylic bur. Then it was finished with a (120) grain size sandpaper for one minute with fixed speed and water cooling. Then it was polished with pumice for 1/2 minute. The other half was prepared in the same manner. By this method the gap space between these two halves was 3 mm with 45 degree flaring upward^{7, 12}.

B. Monomer wetting:

The repair joint was painted with one drop of monomer of the respective acrylic resin, by using a fine brush (NO. zero) at room temperature (22 ± 3 C) for 180 seconds³.

- The same procedure was done for (Acetone) or (Acetone + Monomer) as wetting solvents.

C.1 Repair by cold-cure Acrylic resin (Ivomat) Curing methods:

The repair indices were soaked in water for at least (10) minutes to substitute for a separating medium and allowed to dry for a few minutes.

The two parts of the sample to be repaired were realigned in its repair index and impression compound was placed on the ends of the sample and index to stabilize the combination during repair procedure.

The proportioning for cold-cure is 2.5:1 by volume (P/L). The material was packed into the joint (1) minute after is packed mixing a slight excess of material to account for polymerization shrinkage and finishing.

As the surface of repair material lost its gloss. The repair index with the repaired sample was placed in the Ivomat containing water at (37 C°) and pressure [301 b/ inch²] was applied for (15) minutes.

- The repaired specimens after finishing and polishing will store in distilled water at temperature (37 C°) for (48) hours before testing.

C.2 Repair by cold-cure Acrylic resin (air methods):

The same procedure used in Ivomat curing methods except that repaired samples were placed in air.

Test Equipment and procedure:

The transverse strength of specimens was measured in air by three points bending on an Instron transverse testing machine. TI device was supplied with a central loading plunger and two supports with polished cylindrical surfaces, 3.2 mm and least 10.5 mm long at perpendicular to the longitudinal center line, the distance between the centers of support is in the range of 0.1 mm. the tests were carried with a constant cross head speed of 5 mm/minute \pm 1 mm/minute, the length was measured by a compression load cell of a maximum capacity of 5 kv.

The test samples were held at each end of the two supports, and loading plunger was midway between the supports. The specimens were deflected until fracture occurred. The transverse strength was calculated using the following equation:-

$$S = \frac{3PI}{2bd^2} \quad (\text{Craig and Power, 2002})$$

Where:

S= transverse strength (N/mm²).

P= the load at fracture (N).

I= distance between the supports (mm).

b= width of a specimen (mm).

d= depth of a specimen (mm).

Results

In Table (1) the results showed that the highest mean transverse strength values were obtained in Ivomat and air curing techniques (75.13 N/mm², 72.75 N/mm²) treated with monomer and acetone groups respectively, while the lowest transverse strength values were obtained in Ivomat and air curing techniques (67.23 N/mm², 63.28 N/mm²) with monomer groups respectively, as shown in Figure (9).

Table (2), and (3) the ANOVA test for transverse strength for all tested groups (Ivomat and air methods), the ANOVA test revealed a highly significant differences between the test groups (P<0.001).

Table (4) the LSD test result for Ivomat methods showed that all groups a highly significant difference at (P<0.001).

Table (5) the LSD test results for air methods showed that all groups a highly significant difference at (P<0.001).

Discussion

The flexural strength of a material is the load at which the material fractures under bending load, The results reveal that the repairs with cold-cure acrylic resin in air show lower transverse strength than repairs with cold-cure acrylic in Ivomat, this result may be due to the methods of polymerization influence on the repair resin bonding strength. The results are in agreement with Al- Ani 2000 and Anderoploulos et al. 1991^{7,13}.

On the other hand the results obtained in the present study disagree with those obtained by Lewinstein et al. 1995¹⁴ where he found similar transverse strength for the specimens repaired with cold-cure in air and cold-cure acrylic in Ivomat.

The results of different surface treatment of the repaired acrylic samples for all tested groups are present in Table (1).

The repaired specimens treated with monomer gave higher transverse strength than the control group, this may be due to the repair surface was well dissolved with monomer, bonding cold-cure acrylic resin (repair resin) to the surface of dissolved PMMA. This is based on the formation of a new polymer chains between the acrylic resin pieces because the MMA which act as a solvent will lead to the increase of the functional sites which will produce a stronger sample in transverse strength. The results are in agreement with the results of Rached & Del-Bel Cury 2001 and Valittu et al. 1994^{3, 15} and disagree with Grajower and Goultschin 1984¹⁶. They stated that wetting with monomer only did not increase the sample transverse strength.

Acetone wetting of the repaired surface was stronger solvent than monomer but not as strong as (monomer + acetone). This may be because that wetting the repair surface of acrylic specimens with combination mixture would wash away most, if not all, of the microdebries and create a sponge-like structure, This increase the swelling of repair surface treatment³.

The combination mixture containing [50% monomer of cold-cure acrylic and 50% acetone solvent] wetting of repaired surface raised the transverse strength more than the control, monomer and acetone groups as presented in table (1). This may be due to that the acetone was a stronger solvent than monomer; it increases the swelling of repair surface layer enhancing the diffusion of polymerizable monomer from the repair material and more interwoven polymer networks occurs, also created tight adhesion of the autopolymerizing

and heat-polymerizing resins and causes superficial crack propagation as well as the formation of numerous pits, lead to tight adhesion. This result is supported by the result of Anusavice 1996 and Nagai et al. 2001^{8,10}.

Conclusion

1. The curing methods of cold cure acrylic have a considerable influence on the transverse strength of repaired acrylic specimens; cold-cured resin in air has a lower transverse strength compared with that in Ivomat.
2. Wetting the fractured area with monomer, acetone and combination between monomer and acetone had improved significantly transverse strength of cold-cure acrylic resin.
3. Wetting the fractured area with monomer + acetone for (180) seconds had produced the higher bond strength in both methods of repair compared with control groups.

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Table (1): Descriptive statistics for transverse strength of the control and repaired acrylic specimens.

Studied groups	Methods	No.	Mean	Std. Dev.	Std. Error	Mini.	Maxi.
Control	Control	10	62.90	1.226	0.501	61.90	64.71
Acetone	Ivomat	10	72.648	2.632	1.074	70.10	77.55
	Air	10	69.16	1.119	0.457	67.72	70.22
Monomer	Ivomat	10	67.23	1.068	0.436	66.12	68.62
	Air	10	63.28	1.901	0.775	60.12	65.24
Acetone + Monomer	Ivomat	10	75.13	0.667	0.272	74.61	76.35
	Air	10	72.75	1.829	0.746	70.07	75.65

Table (2) The ANOVA test for transverse strength of Ivomat specimens.

ANOVA test	Sum of Squares	df	Mean Square	F	P-value	Dig.
Between Groups	542.146	3	180.715	72.133	0.000	Highly Sig. (p<0.001)
Within Groups	50.106	20	2.505			
Total	592.252	23				

Table (3) The ANOVA test for transverse strength of Air specimens.

ANOVA test	Sum of Squares	df	Mean Square	F	P-value	Dig.
Between Groups	409.743	3	136.581	56.239	0.000	Highly Sig. (p<0.001)
Within Groups	48.572	20	2.429			
Total	458.215	23				

Table (4) LSD test for control and repaired acrylic Ivomat specimens.

Studied Groups		LSD (f-test)	
		P-value	Sig.
Control	Acetone	0.000	Highly Sig. (P<0.001)
	Monomer	0.000	Highly Sig. (P<0.001)
	Acetone + Monomer	0.000	Highly Sig. (P<0.001)
Acetone	Monomer	0.000	Highly Sig. (P<0.001)
	Acetone + Monomer	0.000	Highly Sig. (P<0.001)
Monomer	Acetone + Monomer	0.000	Highly Sig. (P<0.001)

Table (5) LSD test for control and repaired acrylic Air specimens.

Studied Groups		LSD (f-test)	
		P-value	Sig.
Control	Acetone	0.000	Highly Sig. (P<0.001)
	Monomer	0.000	Highly Sig. (P<0.001)
	Acetone + Monomer	0.000	Highly Sig. (P<0.001)
Acetone	Monomer	0.000	Highly Sig. (P<0.001)
	Acetone + Monomer	0.000	Highly Sig. (P<0.001)
Monomer	Acetone + Monomer	0.000	Highly Sig. (P<0.001)

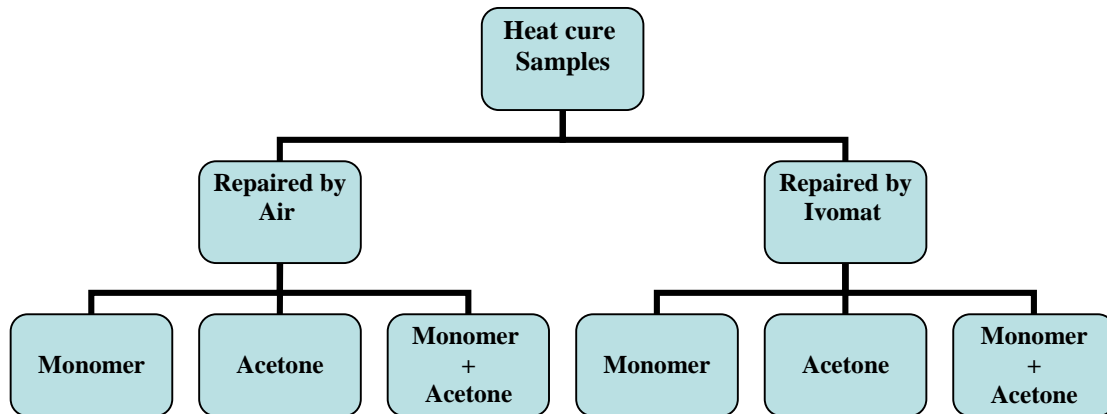


Figure (1)



Figure (2) Acrylic pattern for transverse strength test.



Figure (3 a) Acrylic specimen was cut with fissure bur



Figure (3 b) the cut end was prepared with acrylic bur with 45 degree bevel



Figure (3 c) fracture acrylic specimens was placed in the stone mold.



Figure (4) Monomer wetting with fine brush (No. zero)



Figure (5) Acetone wetting with fine brush (No. zero)



Figure (6) Combination of [Acetone and monomer] wetting with fine brush (No. zero)



Figure (7) device.

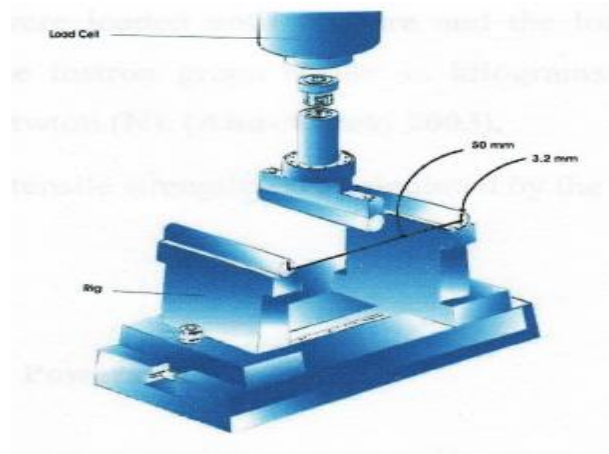


Figure (8) three point transverse testing machine.

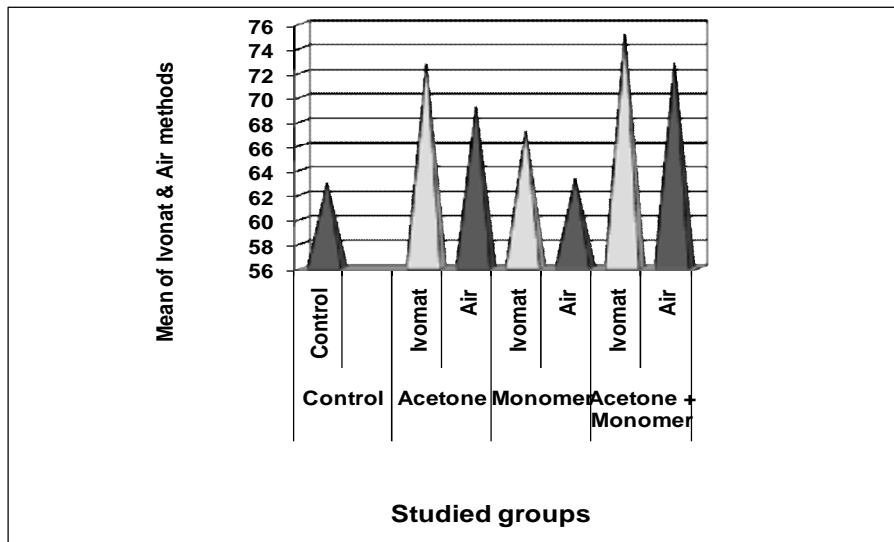


Figure (9): Differences of the mean values of transverse strength of control and repaired acrylic specimens.