Effect of certain chemical surface treatments on repair bond strength of some denture base materials

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ABSTRACT

Background: Fracture of different types of acrylic denture base is a common problem associated with dental prosthesis. Studies suggested that the repair strength may be improved by several means including surface treatment with chemical agents. The aim of the study was to evaluate the effect of surface treatment with acrybond-bonding agent and monomer on fractured denture base in respect to transverse, tensile and shear bond strength and evaluation of the mode of failure by light microscope.
Materials and methods: Two hundred seventy specimens were prepared and divided into 3 groups according to the material used (regular conventional, rapid simplified and high impact) heat cure acrylic. The specimen in each groups were prepared specifically according to testing (tensile, transverse and shear bond strength). All the specimens were stored in 37°C for 28days before fracture then the specimens in each test were divided into 3 groups according to surface treatment (control-without surface treatment, monomer(MMA) group and acrybond (MMA with acetone))group. The specimens repaired with cold cure acrylic using Ivomet; then stored in distill water at 37°C for 2days before testing. GEFRA universal testing machine was used and final load at fracture was recorded.
Results: monomer and acrybond group exhibited higher bond strength than control group.
Conclusion: the type of denture base affect the value of bond strength and the use of monomer or acrybond resulted in higher bond strength than untreated surface.

Key words: Acrybond, mode of failure, denture repair. **(J Bagh Coll Dentistry 2014; 26(1):53-58).**

INTRODUCTION

The fracture of acrylic resin denture base material is a common clinical occurrence. Fracture are more in the midline of maxillary complete denture [1,2]. The fabrication of new denture is an expensive and time consuming procedure for this reason repair a denture is a common one [3] The ultimate goal of any acrylic denture repair is to restore the original strength of the fractured denture and avoid further fracture [1].

Various methods have been proposed for repairing fractured denture base, the use of auto-polymerizing acrylic resin, allowing for simple and quick repair, is the most popular. Successful denture repair relies on the phenomenon of adhesion. Strong bonding of the repaired unit and reduce stress concentration. Adhesion between denture base and repair materials can be improved by applying appropriate chemicals to the acrylic resin surfaces. These chemicals etch the surface by changing morphology and chemical properties of these materials [4]. Normally this change is obtained by wetting the surfaces with (MMA).

Organic solvents such as acetone had also been used for this purpose. The present study was designed to evaluate the effect of 2 chemical solvents methyl methacrylate monomer and acrybond/ bonding agent which composed from (MMA and Acetone) on the (Transverse, tensile and shear) bond strength of the repaired denture base material (Regular conventional, rapid simplified and high impact) and using the light microscope to evaluate the mode of failure whether adhesive, cohesive or mixed.

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MATERIALS AND METHODS

1- Metal pattern preparation:

Three different metal patterns were constructed according to the required tests as follow:

a-For transverse bond strength test; rectangular specimen (65mm x 10mm x 2.5mm) [5].

b-For tensile bond strength test; dumbbell specimen (60mm x 12mm x 3mm).

c-For shear bond strength test which consist of 2 blocks each block were prepared with a dimension (70mm x 12mm x 12mm)[7] length, width and thickness respectively.

2- Silicon stone mould preparation: a-Silicon mould preparation: To facilitate processing of testing, silicon mould was prepared by using a metal tray (Figure l).

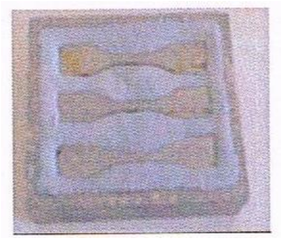

Figure 1: Metal tray

b-Investing procedure:
Silicon mould was poured with stone by using dental flask (Figure 2).

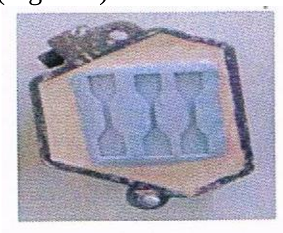

Figure 2: Silicone-stone mould

All materials were manipulated and mixed according to manufacture instructions, then packing, curing, finishing and polishing according to the manufacture instructions and conditioned for 28days at 37°C[5].

Repair procedure for transverse and tensile bond strength test:

With the aid of metal holding device the specimens were fractured with 45° bevel joint with a 3mm gap between fractured parts. The two parts of acrylic was repaired by (Rapid Repair/ Densply) used as a repair material; mixed according to manufacture instructions then packing and curing by using (Ivomet) for 15min. at 37°C and at pressure 301b/ Inch2[8]. After finishing and polishing the specimens were kept in the incubator and stored in distilled water at 37°C for 2 days.

Repair procedure for shear test:

Two specimens were adjusted together to test shear bond strength, this left a space between them filled with repair material. First specimen was adjusted the in a silicon mould then the lower half of giant flask filled with stone, before complete setting of the stone; the specimen with silicon mould were placed in the flask. Then complete investing procedure for packing and curing in (Ivomet) at 37°C and pressure 20Ib/Inch2 for 30 minutes [9], (Figure 3).

c- Shear bond strength test:

Test was done by using GEFRA universal testing (Figure 5) at cross speed (1 mm/min)

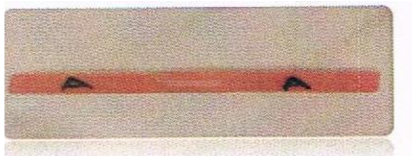

Figure 3: Specimen ready for testing

Preparation of the repaired acrylic specimens with surface treatment was applied on the repair joint before packing with cold cure acrylic, solvents were either:

A- A cry bond-bonding agent (Vertex) which composed from (MMA and acetone) was applied with cotton swap recommended by manufacturer instructions for 180 seconds before packing of cold cure acrylic [10]. B- Monomer (MMA) was applied with fine brush no. zero for 180seconds before packing cold cure acrylic [8].

Mechanical tests a-Transverse bond strength test:

A total of 90 specimens were prepared from the three types of heat cure acrylic materials with different surface treatment, the transverse strength was measured by universal testing machine, (Figure 4)

Figure 4: Universal testing machine

By 3 points bending at cross head speed of (0.5mm/min), the value **was** computed by the following equation: $S= 3PL/2bd^5$

S= Transverse strength (N/mm^2) P=Peak load exerted on specimens (N) L=Distance between supporting rollers (mm) b=Width of the specimen (mm) d=Depth of the specimens (mm)

b- Tensile bond strength test:

The tensile bond strength of repaired specimen was measured by GEFRA universal testing machine at cross head speed (0.5mm/min) (Figure 5). The value was computed by the following equation: T.S=F/A

T.S=Tensile strength (N/mm) F=Force at failure (N) A=Cross sectional area at failure (mm)[11]

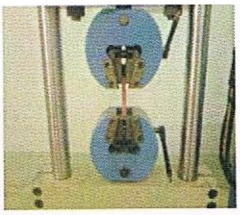

Figure 5: GEFRA universal machine

The value was computed by the following equation:

B.S. = F/S

B.S. = Shear bond strength (N/mm^2)

F = force of failure (N)

S = surface area of cross section (mm^2) (ll)

Effect of surface treatments

Specimens were examined under light microscope (Olympus) to study the effects of application of monomer and acrybond in comparison with non treated surfaces.

Mode of failure

All the specimens were examined visually; this was repeated for all the tested materials under the three types of loading with and without surface treatments.

RESULTS

Mean values, standard deviation and standard error of transverse test are presented in table(l). ANOVA test was used to compare between the surface treatments for every test material. Results of statistical analysis also presented in table 1 also presented in the tables.

Table l: Descriptive data and statistical analysis of transverse bond strength test for the tested materials and surface treatment

Surface treatment	Descriptive statistics	Regular conventional	Rapid simplified	High impact
Control group	Mean	63.60	86.40	73.44
	SD	10.88	10.24	10.63
	SE	3.44	3.24	3.36
Monomer Group	Mean	90.96	94.32	102.00
	SD	5.21	15.23	9.63
	SE	1.65	4.82	3.05
Acrj'bond Group	Mean	97.68	95.52	103.92
	SD	12.43	12.15	7.74
	SE	3.93	3.84	2.45
F-test		32.57	1.52	32.91
P-value		0.000	0.237	0.000
Significance		H.S	N.S	H.S

Duncan's test was used for further analysis to identify the significant surface treatment type in each denture base material regarding transverse bond strength.

Table 2: Duncan test results for regular conventional and high impact heat cure acrylic of transverse bond strength test.

Type of surface Treatments	regular conventional heat cure acrylic		high impact heat cure acrylic	
	Sig	P-value	Sis	P-value
Control & monomer	S	PO.05	S.	P<0.05
Control & acrvbond	N.S	P>0.05	S.	P<0.05
Monomer & acrvbond	N.S.	P>0.05	N.S.	P>0.05

Table 3: Descriptive data and statistical analysis between types of surface treatment regarding every denture base evaluating tensile bond strength test.

Surface treatment	Descriptive statistics	Regular conventional heat cure	Rapid Simplified heat cure	High Impact heat cure
Control	Mean	11.11	18.38	21.00
	SD	1.16	2.72	1.83
	SE	0.369	0.862	0.579
Monomer	Mean	16.96	28.67	25.45
	SD	1.24	2.20	1.24
	SE	0.393	0.696	0.393
Acrybond	Mean	13.53	22.22	21.41
	SD	2.57	2.42	3.71
	SE	0.814	0.768	1.17
F-test		27.30	27.30	27.30
P-value		0.000	0.000	0.000
Significance		H.S.	H.S.	H.S.

Duncan's test was used for further analysis to identify the significant surface treatment type in each denture base material regarding tensile bond strength.

Table 4: Duncan' s test result for the tested denture base materials of tensile bond strength test after surface treatments.

Types of surface Treatments	regular conventional heat cure acrylic		rapid simplified heat cure acrylic		high impact heat cure acrylic	
	Sig	P-value	Sig	P-value	Sig	P-value
Control & monomer	N.S	P>0.05	S	PO.05	S	PO.05
Control & acrvbond	S	PO.05	S	PO.05	N.S	P>0.05
Monomer & acrvbond	S	PO.05	S	PO.05	S	PO.05

Table 5: Descriptive data of shear bond strength and ANOVA test between surface treatments.

Surface treatment	Descriptive statistics	Regular conventional heat cure	Rapid Simplified heat cure	High Impact heat cure
Control	Mean	3.258	3.02	1.762
	SD	0.574	0.466	0.534
	SE	0.182	0.147	0.169
Monomer	Mean	3.460	5.118	3.722
	SD	0.462	. 0.474	0.382
	SE	0.146	0.150	0.121
Acrybond	Mean	4.048	3.942	5.360
	SD	0.713	0.723	0.421
	SE	0.225	0.229	0.133
F-test		4.81	34.37	160.04
P-value		0.016	0.000	0.000
Significance		S	H.S	H.S

Table 6: Duncan test result for tested materials regarding shear bond strength with and without surface treatment.

Types of surface Treatments	regular conventional heat cure acrj'Iic		rapid simplified heat cure acrylic		high impact heat cure acrylic	
	Sig	P-value	Sig	P-value	Sig	P-value
Control & monomer	N.S	PX).05	S	PO.05	S	PO.05
Control & acrybond	S	PO.05	S	PO.05	S	PO.05
Monomer &acrybond	S	PO.05	S	PO.05	S	PO.05

Effect of surface treatment:-

Under light microscope the joint of the fractured surfaces after treatment with monomer for (180) seconds appear porous compared with untreated joint which almost smooth with no channels (Figure 6,7). The joint that treated with acrybond showed more porous than monomer surface treatment (Figure 8).

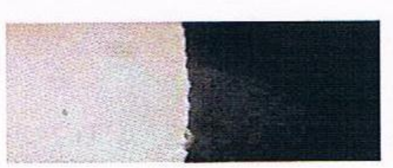

Figure 6: Control (x4).

Figure 7: Monomer surface treatment (x4).

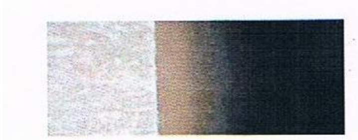

Figure 8: Acrybond surface treatment(x4).

Mode of failure:

The specimens were examined under light microscope to determine the mode of failure. Most of untreated specimens exhibited adhesive type of failure. After treatment with monomer and acrybond the mode of failure was changed to cohesive and mixed type in all the tested denture base materials under different types of loading.

DISCUSSION

Transverse bond strength test

In this study the high impact denture base acrylic resin exhibited the highest mean value then followed by rapid simplified and the lowest was regular conventional . This result were due to too rapid arise in the processing temperature produces a large numbers of radicals and result many growing polymer chains, producing an increase in branching and cross linking of the interstitial polymer. The result are in agreement with Meng and Latte [12] who found that there were high significant difference in the flexural strength observed between high impact polymer and conventional heat cure denture base. For surface treatment the application of monomer for 180 seconds improved the transverse bond strength test and this agree with Abu-Anzeh and Abdul Hadi [8] who stated that wetting the fracture site with monomer before repair will increase transverse bond strength test. While acrybond which dissolve away most of the micro debris and smooth out the adhesive surface and create a sponge like structure and increase bond strength. Our result agree with Vojdani et al [,3] who studied the effect of chemical etchants MMA and acetone on repaired' denture base and found that the transverse bond strength test of repair material to denture base resin increased significantly with chemicals but there no statistically difference between MMA and acetone.

Tensile bond strength test:

In this study the highest mean value was recorded by rapid simplified then high impact and the lowest was for conventional type. These finding suggest that the methods of polymerization recommended by the manufacture of these acrylic resins resulted in a more stable bond. Our finding agree with Vallitu [14] who concluded that the bond of heat polymerizing as well as auto polymerizing base resins to acrylic teeth is satisfactory. For surface treatment the application of monomer for 180 seconds improved the tensile bond strength test by dissolving the outer layer of PMMA. It also improved the adhesion between repaired material and denture base by formation of interwoven polymer network. This was supported by Stoia et al [,5]. For acrybond application also was improved tensile bond strength which supported with result of Sulaiman [10] who found that there was significant improvement in bond strength when using these materials. Indicating that the acrybond is active bonding agent at repaired denture base and these chemicals etch the surface by changing the morphology and chemical properties of the materials.

Shear bond strength test:

In this study the result demonstrated that high impact heat cure denture base showed the highest mean value followed by rapid simplified and the lowest was regular conventional heat cure denture base. This result may be due to the higher polymerization temperature resins enhances the diffusion of monomer of denture base resin into the acrylic resin polymer and further monomer to polymer conversion [16]. Our results agree with Saaverda et al [17] whom observed similar result. For surface treatment the application of monomer for 180 seconds improved the bond strength in all types of acrylic resin. This can be discussed as the chemical surface treatments cause superficial crack propagation as well as the formation of numerous pits approximately 2 um in diameter [18] Acrybond application improved bond strength, it dissolve away and smooth out the adhesive surface and produce sponge like structure which enhance the mobility of monomer units mixed with acetone and form denture base leading to an increase in the number of active sites and then there will be physical interaction (Vander Waal force). This explanation agrees with Sulaiman [l0]. Result from visual examination under light microscope showed high percentage of adhesive failure for untreated repaired specimen indicating the bond failed at the interface of the fractured surface and repaired material. This was agreement with Abdul Hadi [8]. After surface treatment of the fractured ends showed high percentage of cohesive and mixed failure indicating that a strong bond was formed between repaired joint and repaired material thus rendering the fracture to be either through original acrylic specimens or repaired material. Our finding was agreement with the result of Rached and Del-Bel Cury [4] and Abdul-Hadi [8].

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