THE EFFECT OF FIBER REINFORCEMENT ON TENSILE BOND STRENGTH OF ACRYLIC DENTURE BASE RESIN[+]

تأثير التقويه بالفاييبرات على قوة الشد السطحي لقاعدة الطقم الاكريليكي

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Abstract :

Partial fiber reinforcements have been employed to strengthen dentures both during repair and in the manufacturing process .The reinforcing fibers can be evenly distributed in the denture base polymer or alternatively fiber –rich phase in the denture base polymer can form a separate structure. The result of this study shows that glass fibers can be give higher tensile bond strength than that carbon fibers.

المستخلص:

وجهت الدراسة الحالية نحو تحسين متانة مادة الطقم الأكريليكي بالتعزيز بألياف الزجاج والكاربون المضاف الـــى رانتج الأكريليك الذي بلمر بطريقتين مختلفتين . أكدت النتائج المستحصلة أن اضافة الياف الزجـــاج الـــى رانـــتج الأكريليكي قد حسنت من متانة الطقم الأكريليكي افضل من الياف الكاربون .

The aims of this study was

***Evaluate the effect of using various modification on the tensile bond strength of the acrylic resin samples, including:**

- **Reinforcement of the acrylic resin with addition of carbon and glass fibers.**
- **Using of different (pink and clear heat-cure acrylic resin) materials.**

Methods

Thirty specimens were prepared with a dumbbell –shaped metal pattern of (65 mm x 12.5 mm x 2.5 mm) length ,width and thickness respectively was constructed for the tensile bond strength test and were divided according to the type of material into (15) specimens from pink heat – cure acrylic resin and (15) specimens from clear heat – cure acrylic resin.All materials were mixed and manipulated according to manufactures instruction. Two types of fibers were used in this study that glass fiber (1.5% wt) and carbon fiber (0.25 % wt) ,An electronic balance with accuracy (0.0001 g) was used in these study . Mixing procedure of fiber with heat –cure material was performed by hand with continuous mixing until the material look homogenous. The test specimens was measured by instron universal testing machine at cross head speed 0.5 mm/ min. and the chart speed was 20 mm/ min. . The result of this study shows that the addition of glass and carbon fibers to the clear and pink heat – cure acrylic resin groups had improved significantly tensile bond strength compared with specimens that have no fibers add to the heat –cure acrylic resin (control groups) and glass fibers groups can be give higher tensile bond strength than that carbon fibers groups .

Introduction:

[+]Received on 6/10/2008 , Accepted on 22/3/2009 .

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Acrylic resin is based on polymathyl methacrylate (PMMA) is one of the materials routinely used for the manufacture of removable dentures. The favorable working characteristics, ease of manipulation and polish ability, its use in combination with inexpensive equipment, stability in the oral environment and the aesthetics of acrylic resin have resulted in its extensive use as a denture base polymer. However, the acrylic resin denture base polymer has not fulfilled all the requirements in terms of optimum mechanical properties [1] due to its brittle nature under its glass transition temperature (Tg) of approximately 110℃ [2], and its susceptibility to cyclic loading. For this reason, fatigue fracture of dentures is a common clinical manifestation [3,4].It is unlikely that a complete denture would be broken by one heavy biting cycle due to the high volume of the denture base polymer and the geometry of the base plate [5]. However, the thin denture base plates of removable partial dentures can fracture by one loading cycle as a result of a poorly balanced occlusion [6].and a fracture of this kind could result from a static load. Conventional methods employed to reinforce denture base polymers generally involve the use of either metal wires or plates, however, their influence is minor [7,8].

Fiber-reinforced composites (FRC) have been introduced [9,10] to overcome the problem of denture fractures by improving the mechanical properties of the denture base polymer. Partial fiber reinforcements, namely accurate placement of a relatively small quantity of fibers in the denture base polymer, have been employed to strengthen dentures both during repair and in the manufacturing process [9,8] .

Much attention has been directed toward the addition of various types of fibers to acrylic resin to enhance its physical and mechanical properties [11,12]. There are various types of fibers that have been described for this purpose; among them are the glass and carbon fibers [13] . This study has been designed to test the effect of addition of two types of fibers (glass and carbon) fibers on the tensile bond strength of acrylic resin samples cured by two types of resins (pink and clear heat-cured acrylic resin).

Material & Methods:

Materials

Some of the material is used in the present study are :

- Pink heat-cure acrylic resin, Turkey.
- Clear heat-cure acrylic resin, ENTACRYL, Netherlands.
- Fibers as in the table below:

Table (1) Reinforcing fiber used in the study

Fibers	Density	Manufacturing
E- glass fibers*	**2.6 g / cm^3** **450 g / cm^2**	**K and C Moulding Ltd.,UK.**
Carbon fibers	**1.75 g/cm^3** **225 g /cm^2**	**Hyfil Ltd., UK.**

*Composition of E-glass fiber is: 52-56 Wt % SiO_2 , 12-16 Wt % Al_2O_2 ,
16-2 Wt % CaO, 5-13 Wt % B_2O_3 , MgO 0.5% and < 0.1% Fe+Na+K .

Grouping the Specimens:

Thirty specimens (30) were prepared and were divided according to the type of Material into (15) specimens from pink heat-cure acrylic resin and (15) specimens from clear heat-cure acrylic resin. Then tested these groups to tensile bond strength test.
This study included (6) groups of tested specimens are:-
Group AC : (5) specimens (control group) clear heat-cure acrylic with out fiber reinforcement.
Group BC : (5) specimens clear heat-cure acrylic with glass fiber reinforcement .
Group CC : (5) specimens clear heat-cure acrylic with carbon fiber reinforcement .
Group AP : (5) specimens (control group) pink heat cure acrylic without fiber reinforcement .
Group BP : (5) specimens pink heat cure acrylic with glass fiber reinforcement .
Group CP : (5) specimens pink heat cure acrylic with carbon fiber reinforcement .

For the tensile bond strength test a dumbbell-shaped metal pattern of (65 mmx12.5mmx2.5mm) length, width, and thickness respectively was constructed.

All materials were mixed and manipulated according to manufactures instruction, and as recommended by the ADA specification No. 12.
Addition of fibers:
Two types of fibers were used in this study glass fiber (1.5% wt) Figure (1) and carbon fiber (0.25%wt), [14] Figure (2)

Figure (1): Glass fiber

Figure (2): Carbon fiber

short (4mm) length fibers have been cut by the scissors. An electronic balance with accuracy (0.0001g) was used in these study, Figure (3)
Fiber reinforcement percentage % = Wf/Wf+Wm
Wf=weight of fiber
Wm=weight of matrix material

Mixing procedure of fiber with heat cure material was performed by hand and small amount of fibers was gradually carried by mean of tweezers with continuous mixing until the material look homogeneous with no fiber clustering was seen by naked eyes. This hand mixing technique may produce entrapping of air which may result in undetectable voids that may have an effect on the properties of the resultant composite.

Figure (3): Electronic balance

Tensile bond strength test:

- Testing procedure :(30) Heat cure acrylic specimens was measured by Instron universal testing machine with grips suitable for the test specimens, at across head speed of 0.5mm/min and the chart speed was 20mm/min.

A tensile load cell measured with a scale of 100Kg. The recorded force at failure measured. Figure (4).

The tensile strength was calculated by the following equation:

T.S =F(N)/A $(mm)^2$

T.S = Tensile strength (N/mm^2) or (Mpa).

F= Force at failure (N).

A= Cross sectional area at failure $(mm)^2$. [15].

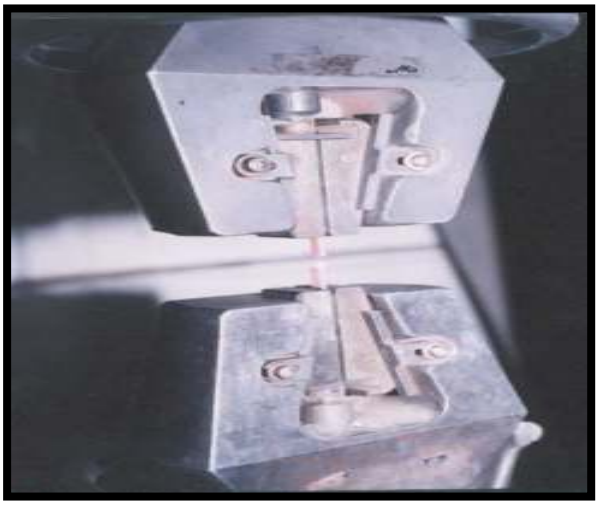

Figure (4): Specimen under tensile load

Results:

Tensile bond strength test

The effect of fiber reinforced on the tensile bond strength test for pink and clear heat –cure acrylic groups:

Table (1) shows the mean, the SD and SE of the tensile bond strength test for the experimental and control group acrylic resin, figure (1)

Table (1): Comparison between of tensile bond strength (N/mm^2) heat- cure acrylic groups pink & clear.

Heat- cure acrylic groups		No.	Mean	Std. Dev.	Std. Error	Mini.	Maxi.
Control	Pink (Ap)	5	42.22	6.46	2.89	37.18	49.30
	Clear (Ac)	5	50.18	5.85	2.62	39.77	53.42
	Total	10	P-value (0.076) Non Sig. (P>0.05)				
Glass fiber	Pink (Bp)	5	44.04	13.12	5.87	34.12	58.42
	Clear (Bc)	5	66.93	18.23	8.15	46.95	80.25
	Total	10	P-value (0.052) Non Sig. (P>0.05)				
Carbon fiber	Pink (Cp)	5	28.29	2.41	1.08	25.65	30.06
	Clear (Cc)	5	30.79	1.61	0.72	29.42	32.53
	Total	10	P-value (0.091) Non Sig. (P>0.05)				

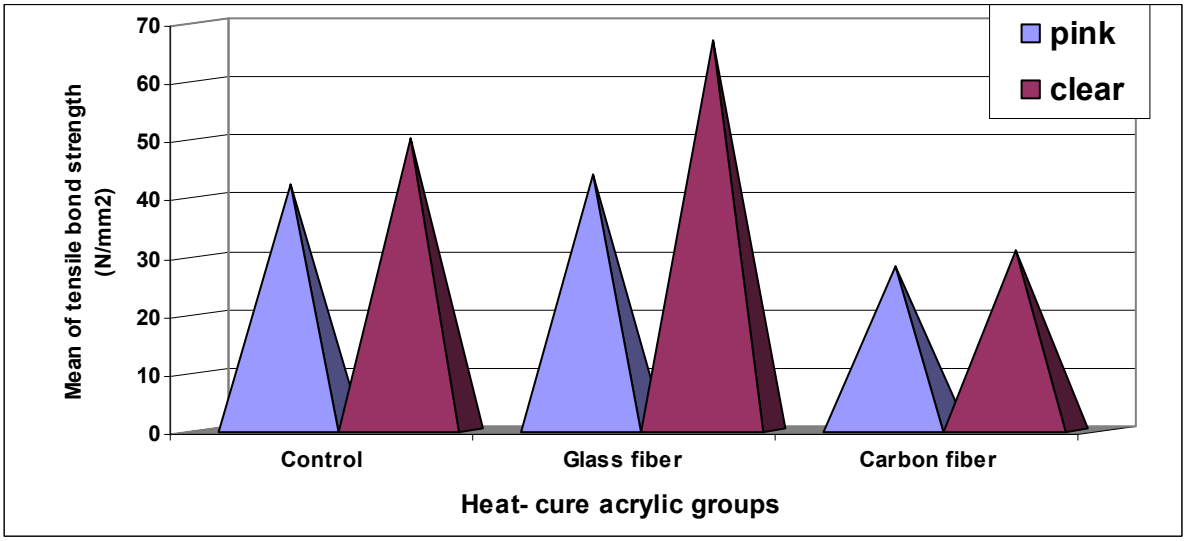

Figure (1): Comparison between of tensile bond strength (N/mm^2) heat-cure acrylic groups pink &clear.

One way analysis of variance (Anova) test revealed a significant difference between the test group ($p < 0.05$) for the pink heat cure specimens .

The source of difference was investigated by further complement analysis of data (least significant difference between the different pairs of the five groups for all tested groups showed a significant difference except for (AP) and (BP) groups which showed a non significant difference.

In the pink heat cure acrylic specimens reinforced with glass fiber the highest mean value were obtained in (BP) group (44.04 N/mm^2) and the lowest mean value in (CP)groups (28.29 N/mm^2) in comparison with control group that have no fiber reinforced with it .

For clear heat –cure acrylic groups one way analysis of variance (ANOVA) test revealed a highly significant difference between the test groups ($p<0.01$) .

The LSD test result showed that all tested groups showed a significant difference except for (BC) and (CC) groups which showed a highly significant difference .

In the clear heat cure acrylic specimens reinforced with glass fiber the highest mean value were obtained in (BC) group (66.93 N/mm^2) and the lowest mean value in (CC) group (30.79 N/mm^2) in comparison with control group that have no fiber reinforced with it .

Discussion

The effect of fiber reinforced on tensile bond strength test for pink and clear heat-cure acrylic groups:

Table (1) shows the results of tensile bond strength with Glass and Carbon fibers add to the tested specimens reinforced with glass fiber for both types acrylic resin used in these study gave higher tensile bond strength than the control groups that have no fibers add to it.

For the heat cure specimens the addition of glass and carbon fibers significantly improve the tensile bond strength when compared with the control specimens that have no fibers add to it. This is due to the fact that the presences of fibers in acrylic resin ensure transferring of loads from matrix to fiber, which eventually arrests the cracks so leading to an increase in the strength of the resin and allowing the resin to tolerate the force of fracture more than the samples that had no fiber in their structure. This result agreement with result of [16] .

The results also showed that the specimens that were reinforced with glass fibers had higher mean Values than the specimens that were reinforced with carbon fibers.

This may be related to the fact that the acrylic resin and glass fiber are different in it is nature, the acrylic resin and carbon fiber are organic in nature, while glass is inorganic, so glass fibers was more compatible with acrylic resin (good molecular interaction) while Carbon fiber was incompatible.

This result disagreement with [14] and these result also which may be attributed to technical Variations and to the use of different materials in these study.

Conclusions

From the result of the present study, the following conclusions could be with drawn:

1- The addition of glass and carbon fibers to the clear and pink heat cured acrylic resin groups had improved significantly tensile bond strength compared with specimens that have no fiber add to the heat cured acrylic resin (control group).

2-The addition of glass fibers to the heat cured resin in the clear and pink heat cure group had improved tensile bond strength higher than the specimens that were cured with heat cure specimens reinforced with carbon fibers.

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