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The Effect of Incorporation of Two Different Fibers on Some Mechanical Properties of Heat Cure Acrylic Resin

Dr. Abdalbasit A Fatihallah BDS, MSc, PhD.
Dr. Mithaq Radhi Mohammed BDS, MSc.
Dr. Yasameen Taha BDS, MSc.
Dr. Zainab Salih BDS, MSc.

Abstract

To evaluate the effect of addition of different fibers on some mechanical properties of heat cured acrylic resin (flexural strength, impact strength and hardness).

210 specimens were used in the study.70 specimens were used for flexural strength with measurements (65mm*10mm*2.5mm) length, width and thickness respectively. The specimens were divided into seven test groups (n=10). The first group is the Control one and it was without fiber reinforcement, second group reinforced with 2mm polyester fibers, third group reinforced with 4mm polyester fibers, fourth group reinforced with 2mm Polypropylene fibers, fifth group reinforced with 4mm Polypropylene fibers, sixth group reinforced with 2mm of both fibers (polyester and Polypropylene), and seventh group reinforced with 4mm of both fibers (polyester and Polypropylene). 70 specimens were used for impact strength in seven group (n=10) with measurements (80mm*10mm*4mm) length, width and thickness respectively. 70 specimens were used for hardness test in seven groups (n=10) with measurements (65mm*10mm*2.5mm) length, width and thickness respectively.

The Results Show that there are highly significant differences between all groups except for a significant differences between control and combination 2 mm fiber length (mean differences=33.45). For the hardness test the comparisons show that there is no significant differences between groups except for a significant differences between control and combination of both fibers with 2mm length (mean differences=-1.34). For impact strength; there are highly significant differences between all groups except for a significant differences between Polyester fiber of 2mm length and combination of the two fiber of 2 mm length (mean differences=-3.1).

In conclusion, the addition of different fibers (polyester and Polypropylene) to acrylic resin gives it more resistance to break and more resistance to bend.

Keywords: Heat cured acrylic resin, polyester fibers, and Polypropylene fibers.

Introduction

Facture of a denture is an important problem not only for patients but also for dentists and dental laboratory technicians.(1)

The failure of a denture base material may often involves either impact failure or fatigue failure. Impact failures involve rapid stressing of a

material such as by dropping the denture on a hard surface. Fatigue failures occur after continued flexing of the base during function may leads to crack development. Failure of this type in an upper denture commonly results in rupture along the midline. [2]

Reinforcement of acrylic resin by incorporation of polyester fibers, which is a category of polymers that contain the ester functional group in their main chain. A specific material, termed "polyester" most commonly refers to polyethylene terephthalate (PET). Polyesters include naturally occurring chemicals, such as in the cutin of plant cuticles, as well as synthetics through step growth polymerization such as polycarbonate and polybutyrate. Natural polyesters and few synthetics ones are biodegradable, but synthetic polyesters are not. Depending on the chemical structure polyester can be thermo plastic or thermoset; however, the most common polyesters are thermoplastic[3,4] .From economical point of view we can use polypropylene fibers for reinforcement of acrylic resin this material is a thermoplastic polymer used in a wide variety of applications including packaging, labeling, textiles (e.g. ropes, carpets) [5,6]. Most common polypropylene is isotactic. It is normally tough, flexible especially when copolymerized with ethylene.[7] Polypropylene can be made translucent but it is not transparent as polystyrene and acrylic. Polypropylene has good resistance to fatigue.[8,9]

The purpose of this study was to evaluate the effect of reinforcement with both of polyester fiber and Polypropylene fiber on flexural strength, impact strength and hardness strength properties of acrylic resin.

Material and Methods

Heat cure acrylic resin (triplex, Ivoclar-vivadent, Germany) used in this study. The reinforcing materials are polyester fiber and Polypropylene fibers. Total specimens were used in this study (210). 40 specimens for each test (flexural strength, impact strength and hardness)

1-flexural strength test:

70 specimens were used in this study and they were divided into 4 groups, each group contains 10 specimens (n=10), metal dies with dimensions of (65 mm*10mm*2.5mm) length, width, thickness respectively following the ISO standard 179-1:2000 (10) were fabricated to prepare the gypsum molds. A thin layer of petroleum jelly applied over the die and it was invested with type IV gypsum product in the lower half of the flask, a layer of separating medium was applied on the stone and metal die, then upper half of the flask was opened and the die was carefully removed from the investing material. Ten molds were prepared. The molds evaluated for any porosities and roughness. The prepared molds immersed in hot water to remove any traces of impurities and to facilitate the application of separating medium. For control group 10 specimens of (PMMA) were fabricated.

Polymer and monomer in the ratio of 2.5:1 by weight mixed and allowed to reach dough stage. It kneaded and packed in the mold. The trial closures performed and excess removed. The two halves of the flask pressed together by bench press. Curing carried out by placing clamped flask in water bath at room temperature raised slowly up to 74°C and holds for 2 hours then raised to 100°C and was maintained for 1 hour. [11]

After completion of polymerization cycle, the flask allowed to cool in water bath to room temperature

specimens were finished and polished after deflasking. The dimension and quality of each specimen were verified and stored in distilled water at 37°C for 24 hours in an incubator before testing the second, third specimen group.

Before mixing of polymer and monomer, polyester fiber and Polypropylene fiber was cut into (2,4mm) were mixed with powder randomly by using the mortar and pestle. The ratio of mixing fibers with powder (2%).

The polymers containing polyester

The test was carried out in air at 21 ± 1°C using flexural testing device (fig 3). A load was applied using a centrally located rod until fracture occurred. The span of this 3-point bending was 50mm.

Specimens set wet from the storage container directly on to the testing apparatus.

All the specimens were tested in the same manner. The ultimate flexural strength (Mpa) of each specimen was determined with the following formula. (12)

$$\alpha = \frac{3 * F * I}{2 * \square * H2}$$

Where α is considered as flexural strength (MPa)
F= the maximum load applied (N)
I = the span between two supports (mm).

2- Impact strength test:

70 specimens with dimension of (80mm X 10mm X 4mm) length, width and thickness respectively were prepared for impact strength test. All the specimens grouped and fabricated similar to the specimens prepared for flexural test. Before testing, the specimens were stored in distilled water at 37°C for 48 hours.

The impact strength test carried out on un-notched specimens. Testing was done on impact testing machine fig (2). fiber (2nd group), Polypropylene fibber (3rd group) and (polyester and Polypropylene fiber combination) (4th group); mixed with monomer in ratio of 2.5:1 by weight and allowed to reach the dough stage, the mixture were packed into the prepared molds, the specimens polymerized and retrieved in the same manner as control group, flexural strength was evaluated according to ISO /Dis / 567 international standard (q) by the 3 point bending test (fig 1).

With pendulum of S2 scale in an air at 23+2°C.

Before testing, pendulum was released to freely swing in the air to record the air resistance (AR) encountered by free-swinging pendulum. Air resistance of 0.9 was taken on S2 Scale where pointer was stabilized after swing. The specimen clamped in position precisely. The pendulum was released and reading indicating energy absorbed (EA) to break the specimen's on S2 scale was recorded. All the specimens tested in the same manner.

Impact strength of specimen calculated by using the following formula:-

$$I = \frac{(EA - AR)}{Xy} = X103$$

I = impact strength in Kj / m2
EA = energy absorbed in joules
AR = air resistance in joules
X = specimen thickness (mm)
Y= specimen width (mm)
H= thickness of specimen (mm)

Hardness strength

70 specimens were fabricated and grouped similar to the specimens prepared for flexural strength test. The test carried out in air at 21±°C using electrical device (share D hardness tester (TH 2 /0) fig. (4), the hardness number based on depth of penetration

and read directly from a gauge.

The mean difference used, standard deviation (St) were calculated for each test and each group (control group), (2mm & 4mm) (polyester fiber group) (2mm X 4mm) (Polypropylene fiber group) and (2mm X 4mm) combination of two fibers (polyester and Polypropylene fibers), to make comparisons between the different groups, independent samples paired t-test was used for analysis.

Results

Table 1, 2 ,3 show the mean values and Standard deviations of the mechanical properties including Flexural strength, Hardness and Impact strength of different length (2mm, 4mm) and types of fibers (control without fiber reinforcement, polyester fiber, Polypropylene fiber and a combination of both polyester and Polypropylene fibers) incorporated into the polymethylmethacrylate resin. (Fig. 1,2,3).

Table 4 shows paired t-test comparison of the flexural strength for all groups. The results show that there are highly significant differences between all groups except for a significant differences between control and combination 2mm fiber length (mean differences=33.45), polyester fiber 2mm length and Polypropylene fiber 4mm length (Mean differences=-18.74) and polyester fiber 4mm length and Polypropylene fiber 4mm length groups (Mean differences=53.84), while no significant differences found between polyester fiber 4mm length and Polypropylene fiber 2mm length (mean differences=2.54), polyester fiber 4mm and combination of both fibers (Mean differences=-11.7) and Polypropylene fiber 2mm and combination of both fibers with 4mm length groups (Mean differences= -14.24).

For the hardness test the comparisons show that there is no significant differences between groups except for a significant differences between control and combination both fibers with 2mm length (mean differences=-1.34), polyester fiber length 4 mm with that of polyester fiber length 2 mm and Polypropylene fiber length 2 mm (mean differences=-1.08 and 0.79 respectively), also combinations of both fibers with 4 mm length shows significant differences with both Polypropylene fibers of 2mm and 4 mm length (mean differences=1.19 and 1.14 respectively.

A highly significant differences have been shown between control group and polyester fiber of both length and Polypropylene fiber of both length (mean differences=-1.60,-2.68,-1.89 and -1.84 respectively).

Also Polyester fiber shows a highly significant difference with both combinations of both fibers of 2 mm and 4 mm length (mean differences=1.34 and 1.9 Respectively.

Table 4 shows paired t-test comparison of the Impact strength for all groups. The results show that there are highly significant differences between all groups except for a significant differences between Polyester fiber of 2mm length and combination of the two fiber of 2 mm length (mean differences= -3.1) and polyester fiber of 2mm length and combination of the two fibers of 2 mm length (Mean differences= 2.1), while no significant differences found between polyester fiber 4mm length and Polypropylene fibers 2mm length (mean differences= 0.04) and Polypropylene fiber 4mm length and a combination of both fibers with 4mm length groups (Mean differences= -0.41).

Discussion

In this study, we examined some

mechanical properties, which were flexural strength, hardness, and impact strength, these properties examined due to its importance in denture strength especially during function like mastication. In flexural strength, the results showed a highly significant between all groups that mean the addition of different fibers (polyester and Polypropylene) give the acrylic resin more resistance to bend [(13)]. A significant difference between 4mm polyester fibers addition and 4mm Polypropylene fibers addition that mean polyester fibers is stronger than Polypropylene fibers and not brittle [(14)]. On the other hand, the results showed a significant difference between 2mm polyester fibers addition and 2mm Polypropylene fibers addition this increase in flexural strength due to random distribution of these fibers make it more resist to bend and also due to plastic property for these fibers [(15)]. In the combination group of these two fibers (polyester and Polypropylene fiber), we see a significant effect on flexural strength in addition to 4mm combination fibers this is due to the same properties of these two fibers and give a double effect of stiffness strength and elasticity to acrylic resin [(16)]. In the second test (hardness test), the results show a significant differences between control group and combination group of 2mm length this increase related to random distribution of these two fibers which give the acrylic resin surface this hardness [(17)]. On the other hand, the addition of polyester and Polypropylene fibers separately in 2mm and 4mm respectively show a significant difference with control group this may be related to the strength of these two fibers [(18)].

The third test we examined was the impact strength, which was important to increase in order to give the denture base the strength needed to be more practical. A highly significant differences between groups that mean the addition of polyester, Polypropylene and combination of both these fibers respectively give the acrylic resin more resistance to be broken this may be related to the absorption of impact by the fibers distributed randomly in the acrylic resin powder that make the smaller cracks disappear between fibers [(19)]. The addition of polyester and Polypropylene fibers in different lengths increase the impact strength this study come in agreement with Waffaa I .M and Intisar J.I.[(20)].

Conclusion

The fracture of denture after dropping was one of the most problems between the patients, so different studies tried to solve this problem, in this study if we want to choose the acrylic resin to make a denture the combination fibers (polyester and Polypropylene) acrylic resin is the type of choose.

References

1- Al–Nema LM, Kassab Bashi T. Evaluation of some mechanical properties of reinforced acrylic resin denture base material (An In vitro study). A1- Rafidain Dent J 2009; 9(1): 57-65.
2- Darbar UR, Huggelt R, Harrison A. Denture fracture. Asurvey.Br Dent J 1994;176: 342-5.
3- Rosato Dominict V, Rosato Donald V, Rosato Matthew V. (2004), plastic product material and process selection handbook, Etevier, pp:85, ISBN 978-1-856/7-B-2.
4- Texyiled, by dstsksfonh Anna lang ford 8th edition, 1998.
5- Maier Clive, Calfut Teresa (1998). Polypropylene: the definitive user's guide and data book. William Andrew.pp:14. ISBN 978-88 4207-58-7
6- Peter J Morris (2005). Polymer pioneers: A popular History of the science and technology of large molecules chemical heritage foundation pp: 76. ISBN 0-941901-03-3.

7- Ray, Hoff, Robert T. Mathers (2010). Hand book of transition metal polymerization Catalysts. John Wieley and Sons.pp:158. ISBN 978-04770 13798-7.
8- E.P. Moore polypropylene Handbook. Polymerization, characterization, properties processing, applications, Hanser publishers: Newyork, 1996 ISBN 156.
9- G. M. Benedikt, B.l. Godall, eds. Metallocene Catalyzed polymers, chem. Tech publishing: Toronto 1998.
10- ISO/DIS 1567. Dentistry: Denture base polymers Geneva: international organization for standarazation, 1998:1-27
11- Zappini G., Kammann A., Wachter W. Comparison of fracture tests of denture base materials. J prosthet Dent 2003;90:578-85
12- lamaza TA, Rosentiel SF, Elhosary MM, Ibraheem RM. The effect of fiber reinforcement on the fracture toughness and flexural strength of provisional restorative resin .J prostht Dent 2004;91:288-264
13- Noe H.ladizeky, Tak W. Chow,Yi Y. Cheng :Denture base reinforcement using woven polyethylene fiber. Int J Prosthodont. 1994;7(4):307-14.
14- AL-Momen M.M. Effect of reinforcement on strength and radiopacity of acrylic denture base material. A master thesis, Department of prosthodontic, college of dentistry, University of Baghdad, 2000.
15- William J.K., James, H.H., and Jefferey Polypropylene:Structure,properties,Manuf acturing process and Applications. P.15-33 in Handbook of polypropylene and propylene composite, Edited by Haruham G. Karian, Mercel Dekler Inc. New York, 1999.
16- Unalan F, Dikbas I, and Gurbuz O. Transverse strength of polymethylmethacrylate reinforced with different forms and concentration of E-glass fibers. OHDMBSC 2010; 9(3):144-7.
17- Salih ZH. The effect of fibers reinforcement on some properties of visible light cured acrylic denture base material. A master thesis, Department of prosthodontic, University of Baghdad, 2006.
18- Sato H. and Ogawa H. Review of development of polypropylene manufacturing process .SUMITOMO KAGAKY (2009); vol. II: 1-11.
19- Mowade T.K., Dange Sh. P., Thakre M.B., and Kamble V.D. Effect of fiber reinforcement on impact strength of heat polymerized polymethylmethacrylate denture base resin:in vitro study and SEM analysis. J Adv. Prosthodont 2012; 4(1):30-36.
20- Waffaa I.M., Intisar J.I. The effect of addition of untreated and oxygen plasma treated polypropylene fibers onsome properties of heat cured acrylic resin (Acomparative study). A master thesis, Department of prosthodontic, College of Dentistry, University of Baghdad, 2013.

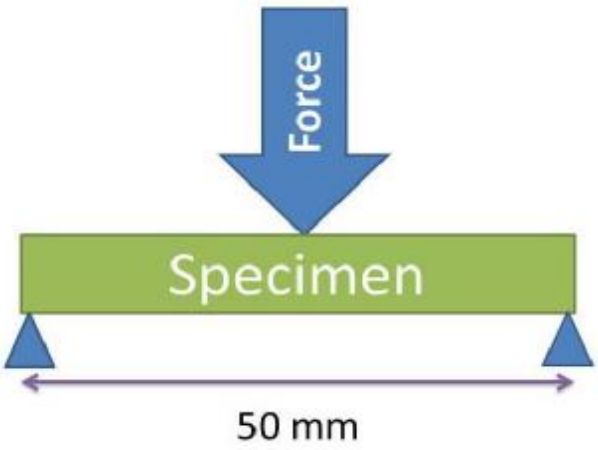

Fig 1: schematic illustration of flexural strength test arrangement.

Table 1: Flextural strength descriptive statistic.

Maximum	Minimum	Std. Deviation	Mean	N	Types of fiber	Length of fiber
284.6	274.21	3.379	280.272	10	Control	
420.8	350.6	22.407	388.005	10	Polyester fiber	2 mm
468.6	450.2	5.405	458.04	10	Polypropylene fiber	
330.4	213.4	38.395	246.82	10	Combination	
284.6	274.21	3.379	280.272	10	Control	
560.6	390.5	53.36	460.58	10	Polyester fiber	4 mm
480.8	382.82	27.675	406.74	10	Polypropylene fiber	
500.4	430.8	21.958	472.28	10	Combination	

Table 2: Hardness descriptive statistic.

Maximum	Minimum	Std. Deviation	Mean	N	Types of fiber	Length of fiber
84.7	80.4	1.2239	82.930	10	Control	
86.0	82.9	1.0155	84.530	10	Polyester fiber	2 mm
85.7	83.9	0.5493	84.820	10	Polypropylene fiber	
85.6	82.9	0.7258	84.270	10	Combination	
84.7	80.4	1.2239	82.930	10	Control	
86.8	84.4	0.8582	85.610	10	Polyester fiber	4 mm
86.6	82.6	1.2526	84.770	10	Polypropylene fiber	
84.8	81.6	1.1441	83.630	10	Combination	

Table 3: Impact strength descriptive statistic.

Maximum	Minimum	Std. Deviation	Mean	N	Types of fiber	Length of fiber
10.1	7.1	1.0807	8.057	10	Control	
19.4	15.3	1.2723	17.910	10	Polyester fiber	2 mm
15.5	11.6	1.1818	13.310	10	Polypropylene fiber	
28.7	17.8	3.2185	21.010	10	Combination	
10.1	7.1	1.0807	8.057	10	Control	
14.6	11.8	1.0201	13.350	10	Polyester fiber	4 mm
18.8	12.8	1.7531	15.400	10	Polypropylene fiber	
18.4	13.6	1.5059	15.810	10	Combination	

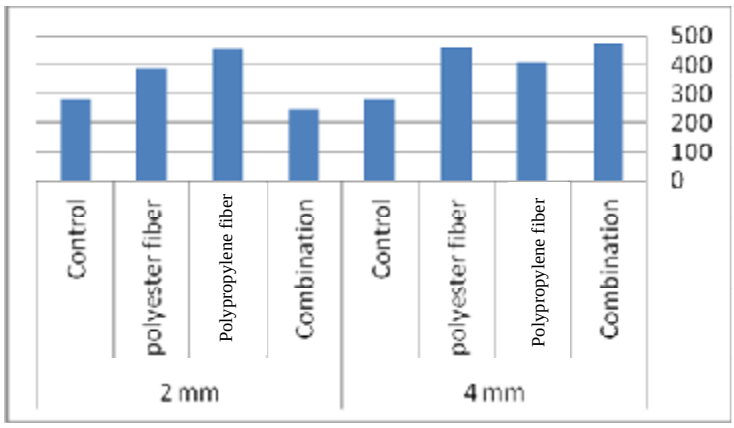

Fig 1: Bar chart represents a mean comparison for flextural strength.

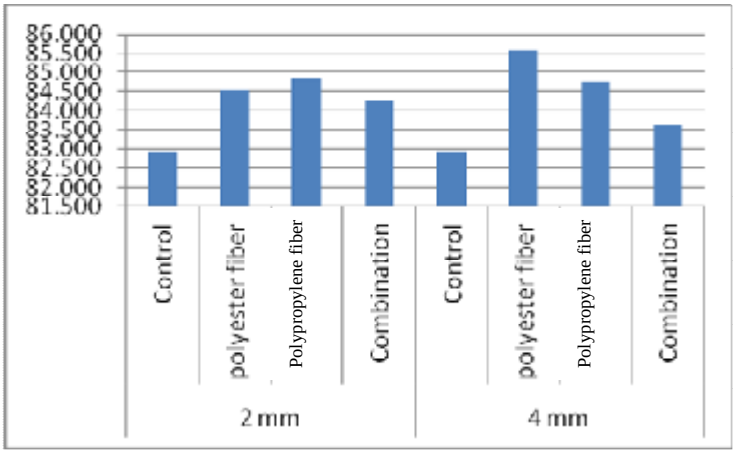

Fig 2: Bar chart represents a mean comparison for hardness.

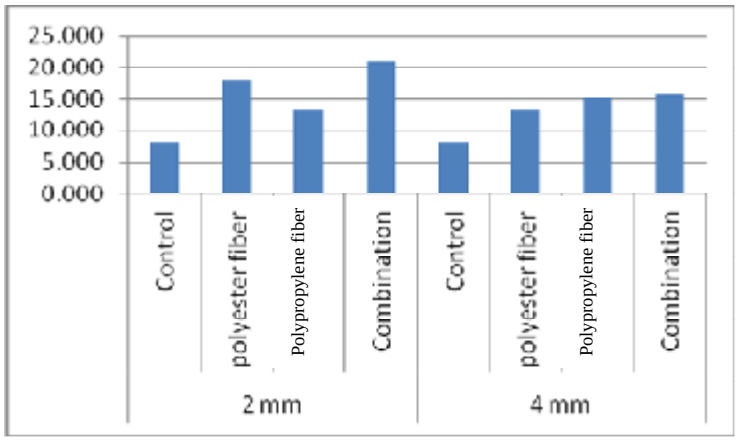

Fig 3: Bar chart represents a mean comparison for impact strength.

Table 4 shows paired t-test comparison of all tests.

Impact strength			Hardness			Flextural strength			Paired Tested
Sig.	t	Paired Differences Mean	Sig.	t	Paired Differences Mean	Sig.	t	Paired Differences Mean	
VHS	-14.916	-9.85	HS	-3.416	-1.60	HS	-14.706	-107.73	Control - PolyF2
VHS	-13.187	-5.29	HS	-7.415	-2.68	HS	-10.348	-180.31	Control - PolyF4
VHS	-15.916	-5.25	HS	-4.197	-1.89	HS	-97.543	-177.77	Control - RubF2
VHS	-10.121	-7.34	HS	-3.784	-1.84	HS	-14.838	-126.47	Control - RubF4
VHS	-10.423	-12.95	S	-3.139	-1.34	S	2.740	33.45	Control - Comb2
VHS	-13.750	-7.75	NS	-1.464	-0.70	HS	-28.170	-192.01	Control - Comb4
VHS	8.195	4.56	S	-3.234	-1.08	HS	-4.023	-72.58	PolyF2 - PolyF4
VHS	8.480	4.60	NS	-0.762	-0.29	HS	-8.894	-70.04	PolyF2 - RubF2
HS	5.228	2.51	NS	-0.507	-0.24	S	-2.439	213.76	PolyF2 - RubF4
S	-3.250	-3.10	NS	0.579	0.26	HS	8.860	141.19	PolyF2 - Comb2
S	3.184	2.100	NS	1.499	0.90	HS	-7.735	-84.28	PolyF2 - Comb4
NS	0.081	0.04	S	2.297	0.79	NS	0.146	2.54	PolyF4 - RubF2
HS	-3.712	-2.05	NS	1.718	0.84	S	2.721	53.84	PolyF4 - RubF4
VHS	-7.135	-7.66	HS	4.370	1.34	HS	9.769	213.76	PolyF4 - Comb2
HS	-3.735	-2.46	HS	4.682	1.98	NS	-0.591	51.30	PolyF4 - Comb4
HS	-3.503	-2.09	NS	0.112	0.05	HS	5.699	51.30	RubF2 - RubF4
VHS	-6.231	-7.70	NS	1.851	0.55	HS	19.396	211.22	RubF2 - Comb2
HS	-3.921	-2.50	S	3.247	1.19	NS	-2.088	231.20	RubF2 - Comb4
VHS	-6.262	-5.61	NS	1.016	0.50	HS	9.907	159.92	RubF4 - Comb2
NS	-0.452	-0.41	S	2.349	1.14	HS	-5.061	-65.54	RubF4 - Comb4
HS	4.617	5.20	NS	1.594	0.64	HS	-16.481	-225.46	Comb2 - Comb4