The Effect of Addition of Combination of Plasma Treated Polyester and Polyamide Fibers on Surface Roughness and Some Mechanical Properties of Heat Cured Acrylic Resin

Abdalbasit A. Fatihallah B.D.S., M.Sc., Ph.D. (1)
Ghasak H. Jani B.D.S., M.Sc. (2)
Zaynab S. Abdullah B.D.S., M.Sc. (1)

ABSTRACT

Background: Poly (methyl methacrylate) has several disadvantages (poor mechanical properties) like impact and transverse strength. In order to overcome these disadvantages, several methods were used to strengthen the acrylic resin by using different fibers or fillers. This study was conducted to evaluate the effect of Plasma treatment of the fiber *on mechanical properties Poly (methyl methacrylate) denture base material*.

Materials and methods: *Specimens were prepared from poly methyl metha acrylic (PMMA) divided according to present of fiber into 4 groups (first group without fiber as control group, second group with Plasma treated polyester fibers, third group with Plasma treated polyamide fibers and fourth group Plasma treated combination of polyester and polyamide fibers. The samples to be treated with oxygen gas plasma*

Results: *the results show that the highest mean values for all tests included in the study appeared in group IV (Plasma treated combination of polyester and polyamide fibers) except for the surface roughness test the highest mean values found in group III (Plasma treated polyamide fibers*, and only polyamide fiber slight improved roughness and other group have no effect on surface roughness

Conclusion *The addition of plasma treated fiber (polyester, polyamide and combination of both fiber) improve transverse, impact strength and hardness properties of denture base material and has no effect on surface roughness*.

Keywords: *polyester, polyamide*, plasma treated fiber. **(J Bagh Coll Dentistry 2018; 30(1):12-16)**

INTRODUCTION

PMMA is the most commonly used materials in construction of dental prosthesis due to its favorable properties like biocompatibility, low cost and easily handling [(1)]. In spite of these advantages, PMMA has several disadvantages (poor mechanical properties) like impact and transverse strength [(2,3).] In order to overcome these disadvantages, several methods were used to strengthen the acrylic resin by using different fibers or fillers [(4,5)]. The polyester fibers one of these fibers which are used to make the acrylic denture base more strong, but due to its elastic properties, these fibers (polyester fibers) increase the impact strength only without increasing the transverse strength [(6,7)]. The poly amide fibers also can be used to the same purpose but also not give the wanted results due to weak interaction between these fibers and acrylic matrix [(8)]. To produce a good results of the use of these fibers, the surface treatment for these fibers is indicated to increase the interaction between the fibers and acrylic resin [(9)].

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

Plasma treatment of the fiber surface one of the most effective methods as it increase the interaction between the fibers and acrylic resin matrix[(10)].
The goal of the present study was to enhance some desirable properties of PMMA by reinforcement with plasma treated polyester and polyamide fibers.

MATERIALS AND METHODS

Specimens were prepared from poly methyl metha acrylic (PMMA) divided according to present of fiber into 4 groups (first group without fiber as control group, second group with Plasma treated polyester fibers, third group with Plasma treated polyamide fibers and fourth group Plasma treated combination of polyester and polyamide fibers.
Before surface modification of fiber with oxygen gas plasma, all fiber should be cleaned with 5% ethanol by use ultrasonic device for 5 min. the fiber left to dry for 10 min., then insert Dc glow discharge plasma device by placing fiber in holder inside the chamber. The samples to be treated were placed on the cathode surface in the center of the cathode assembly of the glow discharge plasma system The distance between the electrodes was 4.5cm and the power supply and voltage adjusted to produce enough current according to the size of the sample Then the Plasma chamber was evacuated to

pressures more than $5X10^{-3}$ mbar using a mechanical rotary pump and then using a turbo pump to increase the pressure to $2X10^{-1}$mbar, when the plasma chamber evacuated, the oxygen gas was introduced in the chamber. after complete the procedure, fiber was storage in close sterilize container.

For each test (transverse strength, impact strength, hardness and Surface Roughness) by using laser cutting machine, construct plastic patterns with shape and dimension according to ADA specification no 57,12 (1999) for transverse strength, surface roughness and hardness and ISO 179 (2000) for impact strength. 160 samples were prepared following conventional procedure for complete denture. [11]

RESULTS:

Phase analysis was studied using 3121 powders X-ray Diffractometer. The 2Ɵ angles were swept from 20-80° in step of one degree. The XRD (Fig. 1,2,3) shown present of fiber in matrix after treated with oxygen gas plasma with no change in chemical stracture.

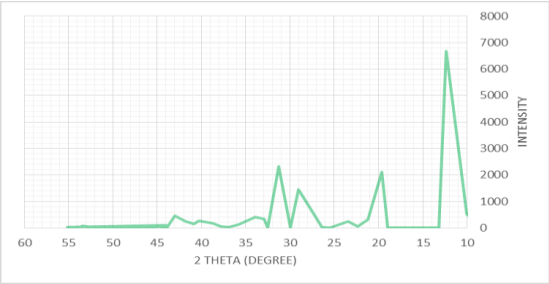

Figure 1: X-ray diffraction patterns of polyester fiber in matrix

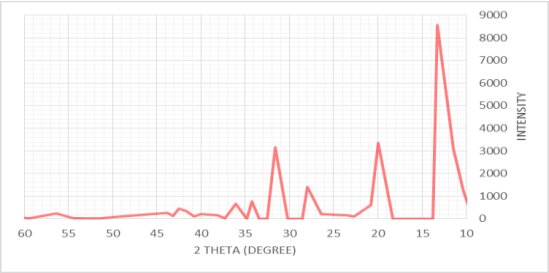

Figure 2: X-ray diffraction patterns of polyamide fiber in matrix

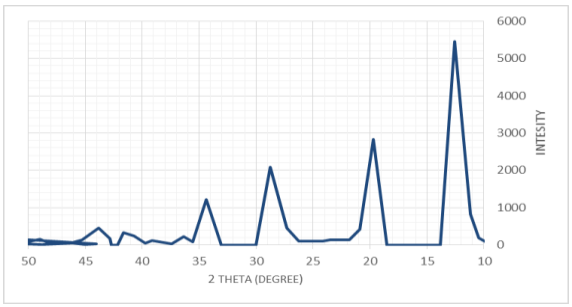

Figure 3: X-ray diffraction patterns of combination polyester and polyamide fiber in matrix

The descriptive statistics shown in table 1 reflect that the highest mean values for all tests included in the study appeared in group IV (Plasma treated combination of polyester and polyamide fibers) except for the surface roughness test the highest mean values found in group III (Plasma treated polyamide fibers). (Fig. 4).

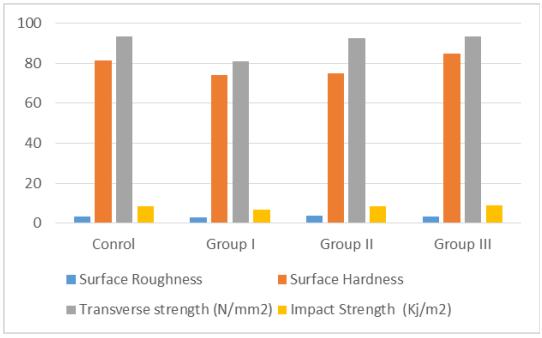

Figure 4: Bar chart plot for mean values for all groups in each test.

When applying ANOVA Table with multiple comparison least significant difference test to compare the mean values within for each test there were highly significant differences between and within groups for surface hardness, transverse strength and impact strength test (p values < 0.01), while no significant differences found between and among groups compared in surface roughness test. (Table 2 and 3).

DISCUSSION

PMMA is commonly use in complete and partial denture prostheses, but unfortunately still this material remained as a weak material to withstand forces during mastication, or fractured due to impact forces [12]. The addition of polyester and polyamide fibers in this study appeared to increase

or improve the properties of heat cured denture base material.

Among the 4 groups used in this study the results showed as presented in table 3 (LSD test) that there is a none significant differences between the groups in surface roughness test except in group III (plasma treated polyamide) group.

The none significant differences in surface roughness of samples in all groups except group III may be due to high density of polyester fibers so there was no effect on surface roughness [14].

In group III (plasma treated polyamide), the surface roughness improves (with mean value 3.65) than control group without any fiber addition (3.37). This may be explained by to low density of polyamide fibers so, it increases surface roughness of the samples [13].

In the hardness test the fourth group (combination polyester and polyamide fibers) showed a high mean value 84.57 than other groups as showed in table 1 that mean there is a high significant differences between this group and the other groups. This increase in surface hardness in group IV could be explained by either disperse of these fibers into the surface of the samples so increasing the surface hardness [15], or due to plasma effect on fiber as increase hardness of fiber, so increasing the surface hardness [15] this results disagree with the results of Jassim which may be due to difference in methodology. [16]

In transverse test, the LSD test showed a highly significant differences between group I and group II, also a highly significant differences between group II and group III, these changes due to the a highly distribution of fibers in 5% concentrations and also to the modification of the surface of these fibers by using plasma treatment after improving of physical and mechanical properties of these fibers[17,18].The significant difference between control group and group II considered to significant statistically but clinically non-significant due to there is no improvement in transverse strength as for control group (93.30) and group II (80.94).

In impact strength the LSD test showed a highly significant differences between control group and group I, this may be related to the elastic nature of polyester fibers with the roughening effect of plasma treatment which make these fibers adhesion increased with acrylic matrix [19-21]. Also a highly significant differences showed between among group II, III and IV these results revealed a double effect of the two fibers which lead to increase the impact strength.

CONCLUSION

The addition of plasma treated fiber (polyester, polyamide and combination of both fiber) improve transverse, impact strength and hardness properties of denture base material and has no effect on surface roughness.

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Table 1: Descriptive Statistical Analysis for all tests and groups.

		N	Mean	Std. Deviation	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Surface Roughness	Group I	10	3.370	0.807	2.793	3.948	2.39	4.66
	Group II	10	2.764	1.013	2.039	3.489	1.11	4.31
	Group III	10	3.655	0.599	3.227	4.083	3.02	4.92
	Group IV	10	3.316	1.164	2.483	4.149	1.35	4.75
Surface Hardness	Group I	10	81.350	1.490	80.284	82.416	79.30	83.60
	Group I	10	74.050	2.145	72.516	75.584	71.30	76.80
	Group II	10	75.010	1.171	74.172	75.848	72.80	77.00
	Group IV	10	84.570	2.918	82.483	86.658	80.80	89.20
Transverse strength (N/mm^2)	Group I	10	93.302	2.228	91.708	94.896	90.10	98.02
	Group II	10	80.945	1.643	79.770	82.120	78.20	83.69
	Group III	10	92.471	3.222	90.166	94.776	86.36	97.39
	Group IV	10	93.382	1.331	92.430	94.334	91.18	95.31
Impact Strength (Kj/m^2)	Group I	10	8.241	0.615	7.801	8.681	7.26	9.30
	Group II	10	6.639	0.580	6.224	7.054	5.45	7.50
	Group III	10	8.388	0.740	7.859	8.917	7.26	9.30
	Group IV	10	8.678	0.505	8.317	9.039	7.80	9.35

Table 2: ANOVA Table for all Tests.

		Sum of Squares	df	Mean Square	F	Sig.
Surface Roughness	**Between Groups**	4.161	3	1.387	1.635	.198
	Within Groups	30.534	36	.848		
	Total	34.695	39			
Surface Hardness	**Between Groups**	767.099	3	255.700	61.213	.000
	Within Groups	150.380	36	4.177		
	Total	917.479	39			
Transverse strength (N/mm2)	**Between Groups**	1104.375	3	368.125	74.316	.000
	Within Groups	178.325	36	4.953		
	Total	1282.700	39			
Impact Strength (Kj/m^2)	**Between Groups**	25.199	3	8.400	22.146	.000
	Within Groups	13.654	36	.379		
	Total	38.853	39			

Table 3: LSD Multiple comparisons among all groups for each test.

		Surface Roughness		Surface Hardness		Transverse strength (N/mm2)		Impact Strength (Kj/m^2)	
		Mean Difference	Sig.	Mean Difference	Sig.	Mean Difference	Sig.	Mean Difference	Sig.
Group I	**Group II**	0.606	NS	7.3	HS	12.357	HS	1.602	HS
	Group III	-0.285	NS	6.34	HS	0.831	NS	-0.147	NS
	Group IV	0.054	NS	-3.22	HS	-0.08	NS	-0.437	NS
Group II	**Group III**	-0.891	S	-0.96	NS	-11.526	HS	-1.749	HS
	Group IV	-0.552	NS	-10.52	HS	-12.437	HS	-2.039	HS
Group III	**Group IV**	0.339	NS	-9.56	HS	-0.911	NS	-0.29	NS

NS: Not significant at P> 0.05, S: Significant at P< 0.05, HS: Significant at P< 0.01

الخلاصة

بولي (ميثيل ميثاكريلات) لديه العديد من العيوب (خصائص ميكانيكية ضعيفة) .من أجل التغلب على هذه العيوب، تم استخدام عدة طرق لتعزيز راتنج الاكريليك باستخدام ألياف مختلفة أو جزيئات نانويةز أجريت هذه الدراسة لتقييم تأثير معالجة البلازما للألياف على الخواص الميكانيكية بولي (ميثيل ميثاكريلات) لقاعدة طقم الاسنان.

المواد والطرق: تم تحضير العينات من بولي ميثيل الميثا أكريليك مقسمة وفقا لألياف الألياف إلى 4 مجموعات (المجموعة الأولى بدون الألياف ، المجموعة الثانية مع البلازما ألياف البوليستر المعالجة، المجموعة الثالثة مع البلازما ألياف البولي أميد المعالجة والرابعة مجموعة البلازما مزيج من ألياف البوليستر وألياف البولي أميد.

أظهرت النتائج أن أعلى القيم المتوسطة لجميع الاختبارات المشمولة في الدراسة ظهرت في المجموعة الرابعة (البلازما المعالجة من مزيج من البوليستر وألياف البولي أميد) باستثناء خشونة السطح اختبار أعلى القيم المتوسطة وجدت في المجموعة الثالثة (البلازما ألياف البولي أميد المعالجة ، وفقط ألياف البولي أميد طفيف تحسين خشونة ومجموعة أخرى ليس لها أي تأثير على خشونة السطح

الخلاصة إضافة الألياف المعالجة البلازما (البوليستر، البولي أميد والجمع بين كل من الألياف) تحسين عرضية، وقوة تأثير وخصائص صلابة من المواد الأساسية الأسنان وليس له أي تأثير على خشونة السطح.