A surface Hardness Estimation of Flexible Acrylic Resin After Glass Fiber Addition

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Abstract

Background*:* Poly methyl methacrylate (PMMA) is commonly used to fabricate removable denture. The development of polymer chemistry produce alternative materials to PMMA such as polyamides (nylon), acetyl resins, epoxy resins …. etc. All these resins are suited for thermoplastic processing; the flexibility of polyamide allows partial dentures be pressed in one piece including clasps. Glass fiber is the most widely used reinforcing material and account or almost 90% of the reinforcement in resins. The addition of fiber to provisional restorative resin increases tensile strength, fracture toughness and surface hardness.***Objective of the study***: Evaluation to improve mechanical property of surface hardness of flexible denture bases by addition of glass fibers and alteration of powder –liquid ratio.

Material and Methods: Forty samples of flexible acrylic were prepared for hardness test and divided into four groups according to fiber addition and alteration in powder-monomer ratio as follows: group (A) consist of (10 specimens) without addition of fiber glass and ratio (3.1 powder- monomer ratio). Group (B) consist of (10 specimens) with addition of fiber glass with (3.1 powder- monomer ratio), group (C) consist of (10 specimens) without addition of fiber glass with (2.5:1 powder- monomer ratio) and group (D) consist of (10 specimens) with fiber glass with (2.5:1 powder- monomer ratio). Surface hardness of all samples were evaluated by Vickers hardness tester after subjected to the load of 25 gm at 15 sec.

Results: The results obtained in the present study showed that significant differences between groups of surface hardness test.

Conclusion: Conclusion was derived that flexible acrylic resin had significant effect after fiber addition and alteration in polymer-monomer ratio.

Keywords: flexible, fiber glass, hardness.

تقدير صلابة السطح للاكريليك الراتنجي المرن بعد اضافة شعيرات الزجاج

زيد عزت عبدالمجيد و أ.م.د. اسراء محمد حمودي

الخلاصة

ان البولي مثيل ميثا اكريلك هو الاكثر شيوعاً لتصنيع الطقم المتحرك. التطوير في البوليمر كيميائياً انتج مواد بديلة عن بولي مثيل ميثا اكريلك مثل البلاستك البولي مايد (نايلون) راتنجات الاستيل، راتنجات الايبوكسي الى اخره. كل انواع الراتنجات ملائمة للمعالجة حرارياً. ان مرونة البولي مايد يسمح للطقوم جزئياً بان تصمم كونه قطعة واحدة متضمنة الكلاب. الشعيرات الزجاجية هي الاكثر استعمالاً كمادة تعزيزية تقريباً (90%) من التعزيز للراتنجات. ان اضافة الشعيرات للتعويضية الراتنجية تزيد من المرونة، الشد، مقامة الكسر والصلابة.

الكلمات المفتاحية : مرنة ، الالياف الزجاجية ، صعوبة .

Introduction

The flexible denture base was introduced in order to improve both aesthetic and functional limitations of conventional removable partial dentures. Flexible denture base resin is ideal for partial dentures and unilateral restorations. The resin is a biocompatible thermoplastic nylon with unique physical and aesthetic properties that provides unlimited design versatility and eliminates the concern about acrylic allergis. The flexible partial allows the restoration to adapt the constant movement and flexibility in patients' mouth. Where it was stated that the flexibility, combined with strength and light weight, provides total comfort and great looks. [1].

Higher nylon elasticity and modeling precision than heat polymerizing PMMA facilitate denture retention by utilizing the undercuts of abutment teeth in the denture base design, so metal clasps can be eliminated from denture bases and problems resulting from metal clasps such as excessive stress on abutment teeth, esthetic comprise, and metal allergy can be eliminated [2].

Various techniques have been devised to improve mechanical properties of the PMMA, one technique is to replace PMMA by another denture base material (e.g., Polyamides, Epoxy resins), or the addition of a copolymer of rubber within PMMA to increase its impact strength. Other options include the use of metallic wires or fiber reinforcement to strengthen the PMMA dentures. Recently, a great emphasis has been placed on the use of glass fibers (GFs) for denture base reinforcement. Various studies have documented the beneficial effect of GFs on the mechanical properties of the denture resins are highly aesthetic and possess excellent mechanical properties. As a result, they are a prime candidate for denture reinforcement. In addition, GFs are highly amenable to bond formation with the

PMMA resins when treated with a suitable silane coupling agent. Appropriate ratio of polymer to monomer is (3 to 3.5:1) by volume or (2.5:1) by weight, this ratio is important to control the workability of the mix and the dimensional changes on setting [3].

Various other mechanical properties such as modulus of elasticity, surface roughness and hardness properties are essential to characterize flexible dentures base materials that are reinforced with GFs [4].

The aims of this study is to investigate the effects of incorporating glass fiber on surface hardness of flexible acrylic resin and the effect of alteration of powder / liquid ratio on this property.

Methods

Samples grouping

A total of (40 specimens) were prepared from flexible acrylic (powder and liquid ,USA) and divided into four groups according to the fiber addition and different powder- Monomer ratio as follows:-

1- Group A (control): 10 specimens without addition of fiber glass with 3.1 powder -monomer ratio
2- Group B (experimental): 10 specimens with addition of fiber glass and 3.1 powder- monomer ratio
3- Group C (experimental): 10 specimens without addition of fiber glass with 2.5:1 powder-monomer ratio
4- Group D (experimental): 10 specimens with addition of fiber glass with 2.5:1 powder-monomer ratio

Samples preparation for Micro Vickers hardness Taste:

Disc shaped with (40×2 mm.) thickness and diameter were prepared. [5] Figure (1) and Figure (2)

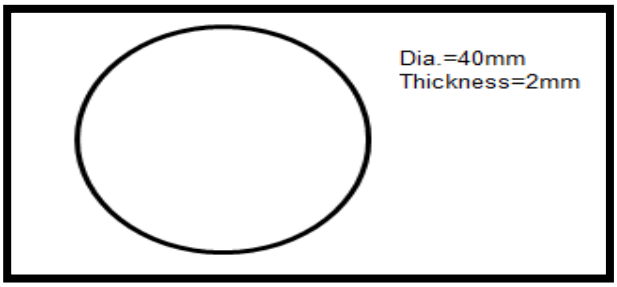

Figure (1): Hardness Specimen.

Figure (2): Specimen for hardness test.

Proportioning and adding the glass fibers

A glass fiber was added to the flexible acrylic resin powder using weight/liquid (w/l) ratio. Addition of glass fiber in amount of 5% by weight of powder and electronic balance with accuracy of (0.0001g) was used for this purpose, as shown in Table (1). The fibers were added to the flexible acrylic powder and mixed and shake well before mixing with the monomer [6].

Table (1): Weight/liquid proportioning of flexible acrylic resin powder and glass fiber to be mixed with a constant amount of liquid.

Groups	Proportioning			
	Weight of flexible acrylic powder (gm)	**Weight of glass fibers (gm)**	**Total weight of the mixture (gm)**	**Amount of the liquid (ml)**
Control	23.4	0.0	23.4	10
5%	22.23	1.17	23.4	10

Proportion and Mixing of Acrylic

Flexible acrylic resin was mixed according to the manufacturers' instruction (3:1), (2.5:1) by volume. A measured volume of liquid was placed in a clean, dry mixing vessel (porcelain vessel) followed by a slow addition of powder, the mixture was stirred with a wax knife, then covered and left to stand until reached the dough stage.

When the stone reached its initial set, it was coated with the separating medium (cold mold seal). Then the upper half of the flask was positioned on the lower half and a second mix of dental stone was poured into the flask and kept under the hydraulic press. After completing the setting of the stone, wax elimination, was done by immersing the flask in boiling water for 4 minutes. Then the flask was opened, washed with boiled water to remove the remaining wax. Then it was allowed to cool, the flask opened again and the surface of the mold was coated with the separating medium [7].

Packing

Flexible Acrylic resin dough was used as recommended by the ADA specification NO. 12 (1999). It was packed in the mold which had been painted with separating medium with the aid of nylon sheet the two halves of the flask were closed together and placed under hydraulic press (1200 psi). Pressure was slowly applied to allow even flow of the dough stage acrylic throughout the mold space. The pressure was then released, flask was opened and the over flowed material surrounding the mold was removed and the flow material around the specimen was cut by a sharp knife.

A second trail closure was performed then the two halves of the flask were finally closed until metal to metal contact had been established and left under the press (1200psi) for 5minutes. (Figure 3 A and B)

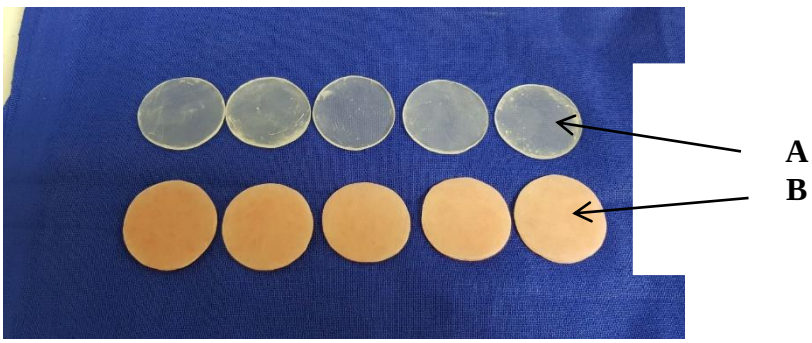

Figure (3): Packing of specimens

Curing

Curing was done in a thermostatically controlled water bath (temperature at (74^{O}C) for (8) hours), after completing the curing, the flask was allowed to cool slowly at room temperature for (30) minutes, followed by another cooling of the flask with tap water for (15) minutes. Deflasking was done and flexible acrylic patterns were then removed from the stone mold [9].

Finishing and polishing

All the flexible acrylic resin specimens were finished by sand paper sheet. While polishing was accomplished by using bristle brush and pumice with dental polishing machine using law speed (1500rpm). The final glossy surface was obtained with wool brush and polishing soap on dental lathe machine [8].

Then the specimens of each material were polished. The abrasive paper was used on all specimens with light manual pressure. A slurry of medium grit pumice mixed in a 1:1 ratio of water was used.

A cloth wheel of Ø=12.5mm for 60sec. at 3,000 rpm on the polishing machine. This was repeated with fine grit pumice. A second cloth wheel, high shine buff was then used with polishing brown Tripoli.

Conditioning of the Specimens

The specimens were conditioned for two days in distilled water at 37°C according to ADA specification No.12 (1999).

Testing Procedure

The Vickers hardness device as shown in Figure. (4) was used in this study. It consists of indenting samples test with a diamond indenter in the form of angle at 136˚ between opposite faces. Figure (5) and right angle Figure (6) . Subjected to the load of (25g at 15 sec.) [11]. The diagonals of the indentation left in the surface of the samples after removed of the load are measured using a microscope and their average calculated; the area of sloping surface of the indentation is calculated. The Vickers hardness quotient obtained by dividing the (f) load by square area of indentation.

Figure (4): Vickers hardness device

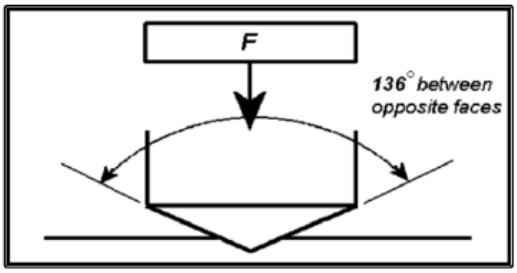

Figure (5): Diamond indenter at 136 angle

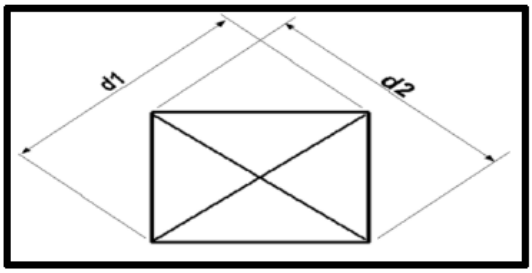

Figure (6): Diamond indenter **at** right angle

HV = Vickers hardness

$$HV = \frac{2F\sin\frac{136^{o}}{2}}{d^{2}} \qquad HV = 1.854\frac{F}{d^{2}} \text{ approximately}$$

Where:

F =Load in Kg f

d =Arithmetic mean of two diagonals d1 and d2 in mm

Results

Micro Vickers hardness test showed that the highest mean values were obtained in control group with normal ratio without fiber addition (3.1 ratio) (4.9110±1.06233) while the smallest one were obtained in specimens of different ratio with fiber addition as shown in table (2) figure (7).

One-way ANOVA showed highly significant differences (P<0.01).

Table (2): Descriptive statistic for Micro Vickers hardness test according to the studied groups.

Studied groups (Micro Vickers hardness test)	*No	Mean	**SD	Std. Error	Range		ANOVA test (P-value)
					Mini.	Maxi.	
3:1 ratio without fiber	10	4.9110	1.06233	.33594	3.67	6.70	
3:1 ratio with fiber	10	3.1510	1.34777	.42620	1.30	5.30	P=0.00
2.5:1 ratio without fiber	10	1.7090	.54206	.17142	1.26	2.75	Highly sign.
2.5:1 ratio with fiber	10	1.5770	.64101	.20270	.92	2.94	(P<0.01)
Total	40						

***No. = Number**

****SD. = Standard deviation**

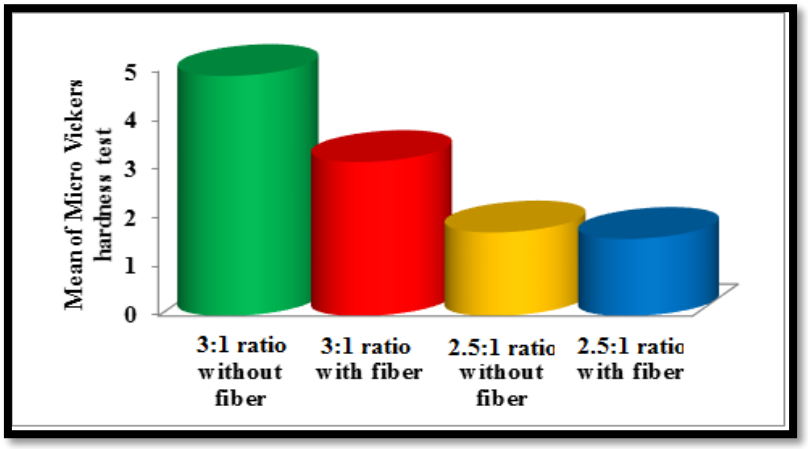

Figure (7): Descriptive statistic for Micro Vickers hardness test according to the studied groups.

*LSD test showed highly significant differences (P<0.01) between normal ratio group with fiber addition (3.1 ratio) and the control group. The only exception observed non-significant differences in group with different ratio without fiber addition (2.5:1 ratio) (P>0.05) as showed table (3).

Table (3): The results of multiple comparison test (LSD) of Micro Vickers hardness between tested materials groups.

Studied groups (Micro Vickers hardness test)		*LSD test (P-value)
3:1 ratio without fiber	3:1 ratio with fiber	P=0.00 Highly sign. (P<0.01)
	2.5:1 ratio without fiber	P=0.00 Highly sign. (P<0.01)
	2.5:1 ratio with fiber	P=0.00 Highly sign. (P<0.01)
2:5 ratio with fiber	2.5:1 ratio without fiber	P=0.002 Highly sign. (P<0.01)
	2.5:1 ratio with fiber	P=0.001 Highly sign. (P<0.01)
2.5:1 ratio without fiber	2.5:1 ratio with fiber	P=0.759 Non sign. (P>0.05)

*LSD = least significant deference.

Discussion

Indentation hardness:

Many methods for evaluating this property have been described including Brinell, Knoop, Viker, Rockwell and Shore d [12].

In this study micro vickers hardness test was used for nylon polymer. Statistical analysis of the results showed high significant difference between nylon groups 3:1 by volume and 2.5:1 by volume with and without the addition of fiber glass as shown in table (2 and 3) Figure (7). This due to Polymerization process leading to the formation of a partial cross linked aliphatic polymer chains giving the acrylic higher hardness [13]. This agreed with Yota (2010) who stated that nylon is a highly chemical resistant material due to its high degree of crystallinity and large crystals with wide interstitial matrix between crystals making the material less resistance. These results disagreed with other work who founded that decreases in the resistance to indenter penetration (slight but non-significant decrease of hardness. It can be concluded that flexible acrylic resin had significant effect after fiber addition and alteration in polymer-monomer ratio.

Conclusion

1. Conclusion was derived that fibers addition significantly affects according to the studied group.
2. Flexible acrylic resin had significant effect after fiber addition and alteration in polymer-monomer ratio.

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