Effect of metal wire and glass fibers on the impact strength of acrylic denture-base resin

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المستخلص

الهدف: الهدف من هذه الدراسة هو مقارنة قوة الإرتطام لمادّة الاكريلك الحار المستعمل في صناعة قاعدة طقم الأسنان عزّزَ بالسلكِ المعدنيّ والأليافِ الزجاجيةِ.

المنهجية: تمّ تحضير ٤٥ عيّنة من مادة الاكريلك الحار ثم قسّمت العيّنات إلى ثلاث مجاميع: المجموعة الأولى تتألف من ١٥ عيّنة (عيّنات مقارنة والمجموعة الثانية تتألف من ١٥ عيّنة مدعومة بسلكٍ معدني والمجموعة الثالثة تتألف من ١٥ عيّنة مدعومة بالألياف الزجاجية. تمّ اختبار قوة الإرتطام لجميع العيّنات بواسطة جهاز فحص قوة الإرتطام.

النتائج: أظهرت النتائج وجود فرقٍ مَعنَويّ عالٍ بين المجاميع الثلاثة.

التوصيات: يمكن الإستنتاج أنّ قوة الإرتطام لمادّة الاكريلك الحار المستعملة في صناعة طقم الأسنان تتحسن إلى حدٍ كبيرٍ بإستعمال السلك المعدنيّ والألياف الزجاجية. على أيّة حال، إضافة الألياف الزجاجية كانت طريقةً أكثرَ فعّاليةً لأَنْ تُحسّنَ قوّةَ تأثيرِ راتنجِ أكريليكِ طقمِ الأسنان الأساسي.

Abstract

Objective(s): The aim of this study is to compare the impact strength of a heat cured denture-base acrylic resin reinforced with metal wire and glass fibers.

Methodology: Forty five specimens were prepared from pink heat cure acrylic resin. Specimens were grouped into; group-I (control group) which consists of 15 specimens with no reinforcement, group-II which consists of 15 specimens reinforced with metal wire, and group-III consists of 15 specimens reinforced with glass fibers. Specimens were tested by using charpy impact machine.

Results: The result showed that there was a highly significant difference in impact strength value among the testing groups at ($P < 0.001$).

Conclusion: The impact strength of heat polymerized denture-base resin was enhanced considerably by using metal wire and glass fibers reinforcements. However, the addition of glass fibers was significantly more effective method to improve impact strength of denture base acrylic resin.

Keywords: **Heat cured denture-base acrylic resin, impact strength, glass fiber, metal wire**

Introduction

One of the most widely used materials in prosthetic dentistry is polymethyl methacrylate, excellent appearance, ease in processing and repair ability make polymethyl methacrylate as an excellent denture base material [(1)]. However, the primary problem is its poor strength characteristics, including low impact and flexural strength [(2)].

Strengthening the acrylic resin prosthesis can be approached by modifying or reinforcing the resin, one of the most common reinforcing techniques is the use of metal wire embedded in prosthesis [(3)]. However, the primary problem of this technique is poor adhesion between resin and wire, and metal reinforced denture base may be unaesthetic as well [(4)]. Another approach is the reinforcement of acrylic resin dentures with fibers, various types of fibers including Kevlar and glass are used for reinforcement of acrylic resin [(5)]. Kevlar fibers are useful in strengthening polymethyl methacrylate; however they produce problems such as difficulty in polishing and poor esthetic [(6)]. Glass fibers are the most common form of all used fibers, they improve mechanical properties of acrylic resin denture base, have easy manipulation and they are esthetic [(7)].

Reinforcement with fibers enhances the mechanical properties of acrylic resin denture base such as transverse strength, tensile strength and impact strength [(8)]. Aydin et al. [(9)] stated that improved transverse strength, impact strength and good esthetic properties of denture base polymers have been noted when glass fiber was used. Alternatively, Kim and Watts [(10)] showed that there is no difference in impact strength between acrylic resin reinforced with metal wires and glass fibers. While, some authors found that transverse strength and impact strength of heat polymerized denture base was enhanced by using glass fiber and metal wire [(11-12)].

The aim of this study was to compare the impact strength of a heat cured denture base acrylic resin reinforced with metal wire and glass fibers.

Methodology

45 specimens were prepared from pink heat cure acrylic resin (major base2/ England), specimens were grouped into:

Group I: 15 specimens without any reinforcement (control group)

Group II: 15 specimens reinforced with metal wire (Dental Morelliltda /Brazil).

Group III: 15 specimens reinforced with glass fibers (manufacturer: K and C moulding Ltd.,UK).

Method

Acrylic resin specimens were prepared from metal pattern. The final dimensions were (65.50 mm X 12.70 mm + 0.15 mm X 3.75 + 0.03 mm) length, width, and depth respectively, with a notch of 1 mm in depth with an included angle of 30º halfway between the two ends of each specimen according to American Standard for Testing Materials (ASTM) [(13)] as shown in figure (1).

Figure 1. Acrylic pattern for impact strength test

The lower portion of the dental flask was filled with dental stone mixed according to manufacturer instructions (i.e.31 ml /100gm); a layer of stone mix was placed on metal block to avoid trapping of air when inserting the metal block into the stone mix after coating with separating media. After stone was set, both the stone and metal patterns were coated with separating media. The upper half of the flask was then positioned on the top of lower portion and filled with stone.

Stone was allowed to harden for 60minutes before the flask was opened. The metal pattern was invested each time when the samples are to be prepared, the flask was then opened and metal patterns were removed from the mould carefully.

Pink heat cured acrylic resin was mixed according to manufacturer's instructions (2.25gm/1ml). The acrylic resin dough was packed into the mould which had been treated with separating medium and covered with polyethylene sheet, the two halves of the flask were closed together and placed under the hydraulic press, and the pressure was slowly applied to allow even flow of the dough throughout the mould space. The pressure was then released, the flask was opened and the over flowed material (flash) surrounding the mould space was removed with wax knife.

A second trial closure was performed, the two halves of the flask were finally closed until an intimate contact had been established and left under the press (1500psi) for 5 minutes before clamping was done and then the flask was placed in a flask clamp maintaining undisturbed pressure during processing.

Curing was carried out by placing the clamped flask in a thermostatically controlled water bath and processed by heating at 74C° for 1.5 an hour and the temperature was then increased to the boiling point for half an hour (short curing cycle) according to ADA specification, No.12 (1999).After completing the curing, the flask was allowed to cool slowly at room temperature for 30minutes, followed by complete cooling of the flask with tap water for 15 minutes before deflasking. The acrylic patterns were removed from the stone mould.

All flashes of acrylic were removed with an acrylic bur. To get a smooth surface, the stone bur should be used followed by (120) grain size sand paper to remove any remaining small scratches with continuous water cooling. Polishing was accomplished by using bristle brush and pumice with lathe polishing machine. A glossy surface was obtained with wool brush and polishing soap on dental lathe using low seeped (1500 rpm) and the specimens were continuously cooled with water to avoid over heating which may lead to distortion of the specimens, the final measurements of the specimens were obtained using the vernier. All the tested specimens were conditioned in distilled water at 37Cº before they were tested according to ADA specification NO.12 (1999).

Preparation of acrylic specimens reinforced with metal wire, figure (2):

The diameter of metal wire used in this study was 0.8 mm; Metal wire were cut into length of 55mm and placed in the middle of polymethyl methacrylate dough. Each specimen was processed as explained for group I.

Preparation of acrylic specimens reinforced with glass fibers, figure (3):

A special type of scissors was used to cut the fibers; the glass fibers used in this study were 6mm in length. An electronic balance was used to weight the amount of fibers; the weight of fibers that used was 0.022 gm, these short fibers were added to the polymer powder and mixed together, after that the monomer was added to the powder and mixed by using mixing spatula. The mixing was done vigorously against the vessel wall to make sure that the fibers were well wetted with monomer and evenly dispersed in the dough mixture, then packing, curing and finishing as described before.

Table 1. Weight of the acrylic resin and fiber used

Powder	Liquid	Fiber	Powder+ Fiber
2.227 gm	1 ml	0.022 gm	2.25 gm

Figure 2. Metal wire used

Figure 3. Glass fibers used

Impact strength testing:

Evaluation of impact strength testing was done according to the procedure given by ASTM [13] with Charpy type impact machine which was supplied with a pendulum as showed in figure (4). The specimens were held horizontally and struck by the pendulum at the center in the notch area of the tested specimens. The scale reading gives the impact energy in (J).

The value of charpy impact strength was computed by following formula of impact strength [13].

Impact strength (KJ/m^2) = E/ TW

Were E is the absorbed energy in (KJ), while T is the thickness of the specimen and W is the remaining width at the center of specimens.

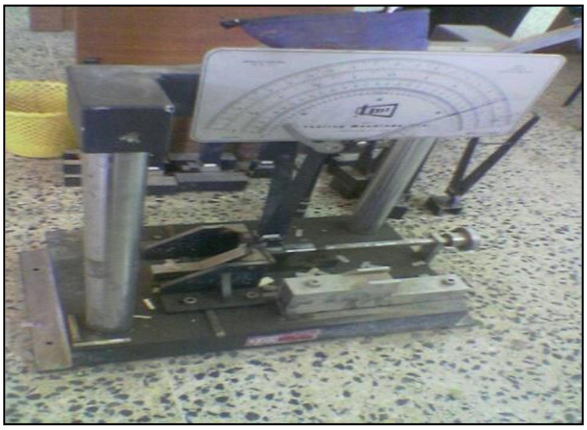

Figure 4. Charpy impact machine

Results

The mean of impact strength for each group is listed in table (2).The mean of impact strength for group-I (control group) was 1.468 KJ/$m^{2,}$ and for group-II (reinforced with metal wire) was 4.853 KJ/m^2 ,while the mean of impact strength of group-III (reinforced with glass fibers) was 8.866 KJ/m^2, figure(5). Also table (2) show the ANOVA test for impact strength for all tested groups and it was found that there is a highly significant difference among tested groups at (P<0.001).

Table 2. Descriptive statistics and ANOVA test for impact strength of studied group

Studied groups	Number	Mean	Std. Dev.	Mini.	Maxi.	ANOVA Test P-value	Sig
Group I (control group)	15	1. 468	0. 010	0. 650	2.665	0.000	HS
Group II Reinforced with metal wire	15	4. 853	0. 350	3. 500	6.900		
Group III Reinforced with glass fibers	15	8. 866	0. 186	6. 550	9.985		
Total	45						

Maxi.= Maximum; Mini.= Minimum; P-value= Level of Probability at p= ≤ 0.001; Sig.= Significance; Std. Dev.= standard Deviation

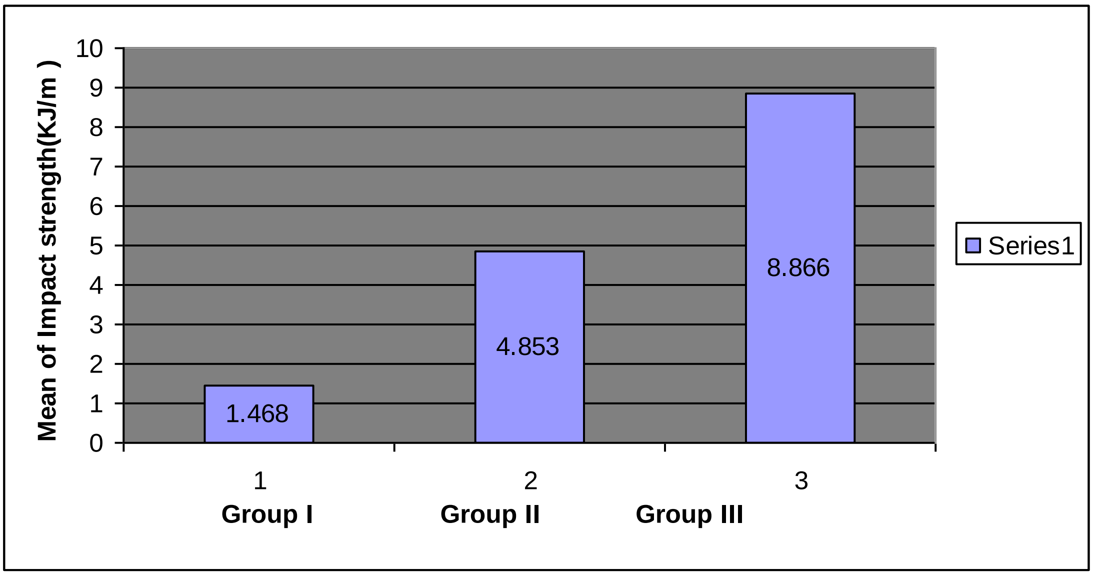

Figure 5. Descriptive statistics for impact strength of studied groups

The LSD test is shown in table (3) which indicated there was a highly significant difference (P<0.001) between each groups.

Table 3. LSD test for control and reinforced groups

Studied Groups		LSD (f-test)	
		P-value	Sig.
Control	Reinforced with metal wire	0.000	HS (P<0.001)
	Reinforced with glass fiber	0.000	HS (P<0.001)
Reinforced with metal wire	Reinforced with glass fiber	0.000	HS (P<0.001)

Discussion

Impact strength is an important property for acrylic denture base material which have tendency to fracture if accidentally dropped on the hard surface [14]. The present study demonstrated the effect of metal wire and glass fibers on the impact strength of denture base resin. It has long been hypothesized that the addition of fibers to the monomer –polymer mixture may strengthen the resultant acrylic resin. Among the many types of fibers, glass fibers considered to be suitable for strengthening the dentures [9]. If fibers are to be used to strengthen a polymer material, optimal adhesion between the fibers and the polymer matrix is essential, impregnation of reinforcing fibers with resin allow fibers to come into contact with the polymer matrix. This is prerequisite for bonding of fibers to polymer matrix and thus for strength of the acrylic [15].

In the present study, specimens reinforced with metal wire showed more impact strength than specimens with no reinforcement which could be due to better bonding between the wire and the resin .This is in agreement with Lassila [3]. Also, the result showed that the specimens reinforced with glass fibers had a clear improvement in impact strength when compared to unreinforced acrylic resin specimens; this could be due to proper impregnation of fibers with resin polymer matrix. This finding comes in agreement with Uzun et al. [16], and disagrees with Vallittu [17]. This could be attributed to the fact that poor wetting of the fibers might result in formation of void space in the acrylic resin –glass fibers. Poorly impregnation of fibers with resin polymer matrix decrease the mechanical properties of the acrylic resin [18].

On the other hand, the result revealed a highly significant differences between the test groups (P<0.001), the impact strength of specimens reinforced with glass fibers was significantly higher than that of metal wire reinforcement. This finding comes in agreement with Vojdani [12]. This could be related to the quantity of fibers in polymer matrix and the good wetting and adhesion of fibers to polymer.

Finally ,the metal wire have a dark color and might pose an esthetic problem ,therefore ,glass fibers can be considered as the choice material for reinforcing acrylic resin denture base. Hence, glass fibers are strongly recommended in patient with heavy occlusal load or when fracture strength of denture base resin is of great concern [12].

Conclusion

According to the result obtained in this study, the impact strength of heat polymerized denture base resin was considerably enhanced by including either metal wire or glass fibers. Moreover, the impact strength of specimens reinforced with glass fibers was significantly higher than that of metal wire reinforcement.

Recommendations

1. Effect of metal wire and glass fibers on the transverse strength of acrylic denture-base resin.

2. Effect of glass fibers and Kevlar fibers on the tensile strength of acrylic

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