The Effect of the Poly Vinyl Chloride (PVC) Addition on Surface Hardness and Impact Strength Properties of Heat-Cured Acrylic Resin Denture Base Material

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ABSTRACT

The most common materials used for fabrication of denture base are poly methyl methacrylate (PMMA) and methyl methacrylate (MMA). Preparation of heat cured, ultered or modified, denture base acrylic resin was carried out by preparing of poly (methyl methacrylate) Polymer, - PMMA- (75%) and poly vinyl chloride -PVC - (25%), and the liquid part composed of methyl methacrylate -MMA- monomer. All the specimens were cured by using short curing cycle (90 min. at 74ºC followed by 30 min. at 100º C). Some mechanical properties of the prepared material were evaluated in comparison with the control denture base acrylic resin. The polymer was prepared by graft copolymerization method. The total 40 specimens, 20 specimens for each experimental or control material were tested.The results showed that the experimental polymer has hardness and impact strength higher than that of control polymer.

Introduction

The most common materials used for fabrication of denture base are poly methyl methacrylate -PMMA- and methyl methacrylate -MMA-.

Acrylic resin has been used successfully for almost 55 years in prosthetic dentistry. Although widely used as denture base material, acrylic resin exhibits certain poor mechanical properties induce fracture that may occur both out side and inside the mouth. Outside the mouth failure occurs through impact failure, as dropping the denture accidentally. Inside the mouth excessive biting force causes fracture [1,2].

Surface Hardness

It is the resistance of surface material to indentation (scratching) from an applied force of sharp point [3]. Historically, the tests for the measured hardness depends on test load and dwell time [4].

The geometry of the indenter of the vicker's pyramidal diamond indenter, makes the result theoretically independent from the test force chosen. These advantages suggest the test as being particularly advantageous in the study of dental materials but as yet very few laboratories are familiar with it and there are no published studies up to date using this particular hardness test in dental materials [5].

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Impact Strength:

Impact strength is a measure of the energy absorbed by a material when it is broken by a sudden blow. Ideally, a denture base plastic would have a sufficient high strength to prevent breakage on accidental dropping, but not at the expense of the other properties [6].

Poly (methyl methacrylate) material is the most commonly used for fabricating removable partial and complete dentures, however, this material presents limitations, particularly in terms of flexural and impact strength [7,8,9].

The underlying causes for denture fracture may be difficult to determine because the much number of variables, including function of denture, handling, and processing [10].

Materials And Methods

20 specimens, 10 specimens for each experimental or control material were tested.

The specimens were cured by using short curing cycle (90 min. at 74ºC followed by 30 min. at 100º C). The polymer was prepared by graft copolymerization method.

Specimens were grouped to two groups:

Group 1: poly (methyl methacrylate) + methyl methacrylate as control. Group 2: poly (methyl methacrylate) 75% and poly vinyl chloride 25% + methyl methacrylate as experimental.

P/L ratio is 2.5:1 by weight [11].

Hardness Equipment

Surface hardness was determined using Durometer hardness tester from type (Shore D) that was fabricated by (TIME GROUP INC) company according to American National Standard / American Dental Association (ANSI /ADA) [11] Ten disk specimens, 22.8mm in diameter and 1.5mm thick, to execute the hardness test by using pointed dibbing tool, where the pointed dibbing tool penetrate the material surface because of the pressure on the instrument where the dibbing tool head touching quite the surface of the samples then the hardness values for the samples were calculated. Impact Strength:

Specimen Design

To evaluate the impact strength of control and experimental group, plastic strips were fabricated as per the dimensions (50×5×4)mm for tests, as specified in the International Standard Organization [12] and British standards for the Testing of Denture Base Resin[13]. A tolerance of ± 0.03mm was accepted. Ten specimens were prepared for each test group and stored in a distilled water at 37˚C until fully saturated (2weeks). The impact specimens were taken from the water and stored in air for 1 hour prior to testing.

Testing Procedure

The impact strength is usually measured by the work required to break a test piece. The testing machine was a charpy type machine tester, and this was designed in such a way that tubs (pendulum) of different weights could be used according to the strength of the materials to be tested. The specimen was clamped at two ends and strict by the swinging pendulum in the area at the center of the tested piece, the average readings gave the impact energy in joules. The absorbed energy by the specimen was noted. The impact strength was calculated using the formula [9]:

Impact strength=E/b×d where:

E- is the absorbed energy.

b- is the sample width.

d- is the sample thickness.

RESULTS

Hardness

Evaluation of the hardness value for experimental material record number 171.22, while specimens of the control material showed hardness value record number 112.80 (table 1).

The statistical analysis indicated that hardness value of the experimental material is significantly higher than that of the control material.

Impact Strength:

From table 2, the mean impact strength value of the experimental material 19.620 N/mm^2 is significantly higher than that of the impact strength value of control material which is 14.604 N/mm^2.

Table 1: Comparison of hardness strength tests (N/mm^2) between experimental and control materials

Groups	N	Mean	S D	S E Mean	t	P
Experimental	10	171.22	11.42	0.59	2.43	0.038
Control	10	112.80	7.45	3.40		

Table 2: Comparison of impact strength tests (N/mm2) between experiment and control materials

Groups	N	Mean	S D	S E Mean	t	P
Control	10	14.604	0.36	0.12	-12.33	0.00001
Experimental	10	19.620	1.05	0.33		

DISCUSSION

Surface Hardness

Shore durometer type D hardness tester eliminate problem with elastic recovery owing to its use of a method that measures the depth of the loaded indentation under loading condition directly by the screen which show the number of it.

Experimental group showed slight increase in hardness more than that of the control group in agreed with [14,15] they showed that high levels of residual monomer adversely affect acrylic resin properties like hardness and porosity. The higher hardness value for experimental is explained by the incorporation of PVC which may increase stiffness and reduced the flow of the material under load which lead to reduction in the creep value. this shows some agreement with [5, 16]. In that the stiffer material shows less creep as compared to the softest material. Also the experimental specimens are showed less porosity than control.

Impact Strength

In this study, the two groups indicated that the impact strength of the experimental group is significantly higher than that of the control group. The presence of porosity in control group more than that of experimental group led to decrease impact strength

of control group, this finding is in agreement with [17] which revealed that the significant porosity can severely weaken an acrylic resin prosthesis. Also, high percentage of water sorption of control group led to decrease impact strength (because of the holes in the interface region) , this is in agreed with [18, 19] they stated that the water absorption decreased mechanical properties of the material possibly because of its effect on the adhesion between the fibers and matrix.

The experimental group prepared by graft copolymerization method may increase the rigidity of the experimental materials, this in agreement with [7, 16, 20] they found that the denture base resins marketed as high strength are commonly graft copolymer materials and offer an improved impact strength when compared with conventional heat-cured acrylic resin.

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تأثير إضافة بولي فنيل كلوريد على خواص الصلادة وقوة التصادم لمادة طقم الاسنان المبلمرة حراريا

احسان علي عبد

الخلاصة:

:تهدف هذه الدراسة إلى إضافة مادة بوليمر فنيل كلوريد الى مادة بوليمر مثيل ميثااكريلات التي تعتبر أكثر المواد شيوعا في عمل طقوم الأسنان البلمرة حرارياً ودراسة بعض الخواص الميكانيكية مثل الصلادة وقوة التصادم بالمقارنة مع مادة بوليمر مثيل ميثااكريلات (المادة القياسية). في هذه الدراسة تم تحضير بوليمر مثيل ميثااكريلات (75%) وبوليمر فنيل كلوريد (25%) وتم خلطهما مع سائل مثيل ميثااكريلات باستخدام طريقة البلمرة المشتركة المطعمة. تم تحضير 40 عينه بمعدل 20 عينه لكل اختبار من كل ماده.أظهر النتائج ان الصلادة وقوة التصادم لعينات المادة التجريبية أكبر منه في عينات المادة القياسية وكان هذا الاختلاف غير معنوي إحصائيا. وهذا يعود لوجود مادة البوليمر فنيل كلوريد الذي أعطى المادة التجريبية أكثر تماسكا من المادة القياسية.