Comparison of some physical properties of acrylic denture base material cured by water bath and microwave techniques

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ABSTRACT

This study was designed to evaluate the physical properties (porosity and transverse strength) for microwave cured acrylic resin using new Iraqi microwavable flask.

For transverse strength test, 20 acrylic samples were prepared with dimensions 65 × 10 ± 0.03 × 2.5 mm. Ten samples were processed by conventional water bath technique, while the other 10 samples were prepared by microwave technique using new Iraqi microwavable flask. The transverse strength of the acrylic samples were measured by three–point bending test.

For porosity test, 16 acrylic samples were prepared with dimensions 65 × 55 × 2.5 mm. Eight acrylic samples were processed by conventional water bath while the other 8 samples were processed by microwave technique using new Iraqi microwavable flask. Evaluation of porosity occurrence was done using microscope at 20× and 40× magnifications.

The results of student's t–test showed that there are no significant differences ($p > 0.05$) in transverse strength for samples cured by water bath and microwave techniques while microscopical examination revealed that all acrylic samples which cured by both techniques were free from porosities.

It was concluded that new Iraqi microwavable flask could be successfully used in curing of acrylic denture base material by microwave technique.

Key Words: FRP flask, transverse strength, porosity.

الخلاصة

تهدف هذه الدراسة إلى تقييم مدى كفاءة البوتقة البلاستيكية المدعمة بالألياف الزجاجية والمصنَّعة محلياً في بلمرة مادة قاعدة الطقم الأكريلية بواسطة الموجات الدقيقة وذلك من خلال فحص القوة المستعرضة ومسامية الراتنج الأكريلي المبلمَر بواسطة الموجات الدقيقة وباستخدام البوتقة البلاستيكية المحلية الصنع، ومقارنة النتائج مع نتائج الراتنج الأكريلي المبلمر بطريقة الفرن المائي التقليدية.

تم تحضير ٢٠ نموذج أكريلي وبأبعاد ٦٥ × ١٠ ± ٠.٠٣ × ٢.٥ ملم لاختبار القوة المستعرضة؛ حضِّرَت ١٠ نماذج بطريقة الفرن المائي و١٠ نماذج أخرى تم تحضيرها بطريقة الموجات الدقيقة وباستخدام البوتقة البلاستيكية المحلية الصنع. تم فحص القوة المستعرضة للنماذج بطريقة اختبار الالتواء الثلاثي النقط.

ولغرض دراسة المسامية للنماذج تم تحضير ١٦ نموذج أكريلي وبالأبعاد ٦٥ × ٥٥ × ٢.٥ ملم، حُضِّرت ٨ نماذج بطريقة الفرن المائي و٨ نماذج أكريلية أخرى بطريقة الموجات الدقيقة وباستخدام البوتقة البلاستيكية المحلية الصنع؛ ثم فُحِصَت جميع النماذج الأكريلية بواسطة الميكرسكوب للتأكد من وجود المسامية أو عدم وجودها.

أظهرت نتائج التحليل الإحصائي عدم وجود فروقات معنوية (عند مستوى معنوية ٥%) في القوة المستعرضة للنماذج المبلمرة بكلتا الطريقتين. كما أظهرت نتائج الفحص المجهري أن كل النماذج المبلمرة بكلتا الطريقتين كانت خالية من المسامية.

يُستنتَج من هذه الدراسة أن البوتقة البلاستيكية المدعمة بالألياف الزجاجية والمحلية الصنع يمكن استخدامها بنجاح في بلمرة مادة قاعدة الطقم الأكريلية بواسطة الموجات الدقيقة.

INTRODUCTION

Acrylic resin has been used in the construction of denture bases since 1930s.[1] Traditionally acrylic resin for denture bases has been compression molded and processed in brass denture flasks.[2] The packed flasks are usually placed in a temperature–controlled water bath for a specified time to polymerize the resin. Acrylic resin for denture bases may also be polymerized with microwave irrad-iation as developed in 1968 by Nishii.[3]

There are substantial advantages if the acrylic resin is cured by microwave energy rather than the conventional water bath method. The advantages are greatly reduced curing time, less cumbersome equipment and a cleaner method of proc-essing.[4] Because metal flask can not be used for microwave processing, a fiber–reinforced plastic (FRP) flask system was developed and became commercially av-ailable in 1985.[5] Unfortunately, the most disadvantages of microwave technique were related to these FRP flasks as the flask is relatively expensive and has a tendency to break down after processing several dentures.[6]

So, in previous work, a novel metal mold was designed and constructed to be used for production of new Iraqi FRP flask with relatively low cost and simple pro-cessing method.[7]

This study was designed to evaluate the physical properties of transverse stren-gth and porosity for microwave cured acrylic resin using new Iraqi FRP flask which was produced by the metal mold.

MATERIALS AND METHODS

Master wax plates with 65 × 55 × 2.5 mm length, width and thickness respec-tively were prepared for transverse stren-gth and porosity test using modeling wax (T.P regular, Major Prodotti Dentari, S.P.A., Italy).

By the use of dental stone (Silky Rock, Whipmix Lousiville, USA) as inv-estment material, these wax plates were invested in their corresponding flasks.

After wax elimination, a fine brush (no. zero) was used to spread the sepa-rating medium (Isol Major, Major Prodotti Dentari, S.r.I., Italy) onto the exposed surfaces of a warm, clean stone molds.

Powder and liquid of heat cured acrylic resin (Major Base 2, Major Pro-dotti Dentari, S.P.A., Italy) were propor-tioned and mixed according to the manu-facturer's instructions.

Then the flasks were packed with acrylic resin material. Packing was done at the late dough stage indicated by the clean separation of the resin from the walls of the glass–mixing jar.

✍ Curing cycle for microwave technique

New Iraqi FRP flask was placed in the microwave oven (Samsung, Model RE–570 D, 0.6 cuft, Korea) for 30 minutes at the low setting (80 watts): 15 minutes per side, followed by 1 ½ minutes at the high setting (500 watts).[8]

✍ Curing cycle for conventional water bath technique

The resin was cured in two steps polymerization, 70 ºC for 30 minutes, then proceed at 100 ºC for 30 minutes (acc-ording to the manufacturer's instructions), in a thermostatically controlled water bath.

Transverse Strength Test

After preparing of 4 acrylic samples with dimensions 65 × 55 × 2.5 mm, 2 samples by water bath technique and the other 2 samples by microwave technique, finishing and smoothing were conducted by using silicone carbide grit papers. First grit 120 was used, then finally by grit 600, then samples were polished with polishing cloth and soap according to ADA Spe-cification no. 12.[9]

Then each acrylic sample was cut carefully into five pieces (using a band saw); each measuring 65 × 10 $\pm$ 0.03 × 2.5 mm[10] (Figure 1).

The total number of samples for transverse strength was 20: Ten acrylic samples were cured by conventional water bath, while the other 10 acrylic samples were cured by microwave technique.

After that, all samples were stored in distilled water at 37 ºC by the use of an incubator (Memmert GmbH + CoKG, Germany) for 48 hours.[10]

The transverse strength of acrylic samples was measured by three–point bending test that closely resemble in service condition (Figure 2).

The sample was supported at each end by a roller of 3.2 mm diameter, dist-ance between the two rollers was 50 mm.[10]

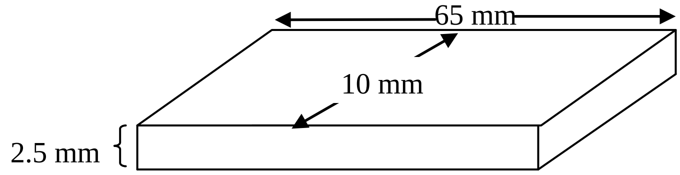

Figure (1): Dimensions of acrylic sample for transverse strength test

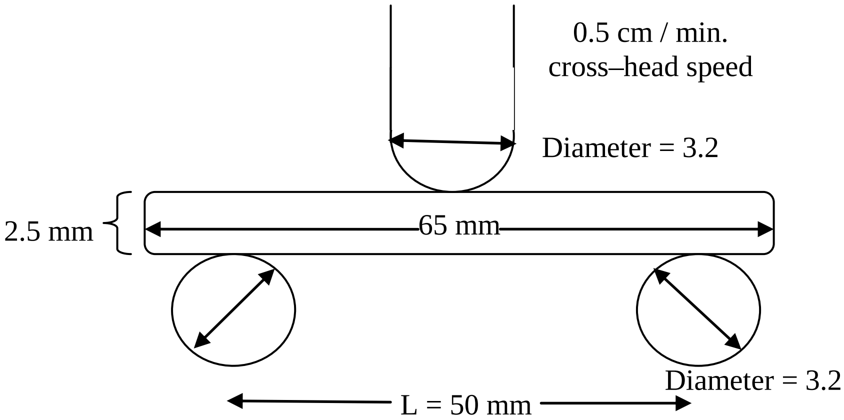

Figure (2): Transverse strength test diagram

The load was measured by a compression machine (Inc. Model CN 472, EVANSTON, Ill–USA) at cross–head speed of 0.5 cm per minute.

Transverse strength (TS) calculated by the following equation:[11]

TS = 3 WL/2bd^2

W= Maximum load at midpoint of the sample (Kg)

L= Distance between the supports (50 mm)

b= Width of the sample (10 mm)

d= Thickness of the sample (2.5 mm)

Porosity Test

Eight acrylic samples with dimensions 65 × 55 × 2.5 mm were processed by microwave technique using new Iraqi FRP flask and the other 8 acrylic samples with the same dimensions were prepared by conventional water bath technique.

These acrylic samples were finished and polished using the procedure described in the previous test.

These acrylic samples were arranged and examined under the light microscope (Olympus, Japan) using 20× and 40× magnifications.[12]

RESULTS

For transverse strength test, student's t–test was conducted (Table 1) and revealed that there are no significant differences (*p*> 0.05) in transverse strength of samples cured by both techniques.

For microscopical examination of 16 acrylic samples cured by water bath and microwave techniques, the results showed that all samples were free from porosities (Table 2).

Table (1): Transverse strength test

Curing Technique	Number	Mean $\pm$ SD (Kg/cm^2)	df	Significance
Microwave	10	960.381 $\pm$ 108.846	18	0.343*
Water Bath	10	1671.964 $\pm$ 2308.976		

SD: Standard deviation; df: Degree of freedom.
* No significant difference at *p* > 0.05.

Table (2): Porosity test

Curing Technique	Number of Samples							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Microwave	n	n	n	n	n	n	n	n
Water Bath	n	n	n	n	n	n	n	n

n: Negligible amount of porosity

DISCUSSION

Transverse Strength Test

Transverse strength test is widely used for evaluation of quality of acrylic denture base material as the test condition approximate to in–service condition as closely as possible.[13]

During mastication, a load applied through the teeth of a denture forces the base against the hard tissue of the mouth. The difference in compressibility of the soft tissue lying between the bone and denture are such that dentures may bend about their midpoint.

In dentistry, transverse strength test is usually carried out on acrylic samples with 2.5 mm thickness, supported across distance of 50 mm. These dimensions represent the average thickness and molar to molar distance in dentures.

The results of present study showed that there are no significant differences in transverse strength of acrylic samples cured by both curing techniques (Table 1). This revealed that using of Iraqi FRP flask provide adequate polymerization of acrylic samples by microwave irradiation that resist mechanical failure similar to that acrylic samples that cured by conventional water bath technique. These findings are in agreement with the findings reported by other studies.[14–16]

Porosity Test

Porosity in denture base resins is a long standing problem[17] as it provides adequate place for accumulation of different types of microorganisms and seriously weaken an acrylic resin prosthesis.[18]

Studies revealed that generation of porosity in denture base resin is a complex phenomenon with multifactorial origins.[19]

The results of this study showed that there is no porosity in all acrylic samples were cured by conventional water bath or microwave technique (Table 2).

It was recommended that there is risk of porosities in thick samples (more than 3 mm thickness) cured by microwave irradiation unless lower wattage and longer curing cycle are used.[15, 20, 21]

In this study, thickness of acrylic sample was 2.5 mm,[10] lower wattage (80 watts) and longer curing cycle (30 minutes, 15 minutes per side, followed by 1½ minutes at 500 watts) was used for microwave curing method.

This curing cycle enhanced the exothermal heat to be dissipated quickly to the surrounding investing stone, and the low wattage that was selected for the curing facilitates spreading of heat in a gradual manner so that boiling point of the monomer which is 100.3 ºC is not reached. This is the possible explanation for the fact that the sample that cured by microwave technique in this study was free of porosities. The results of this study go on lines with other studies.[12, 22, 23]

CONCLUSIONS

Iraqi FRP flask that produced by the novel metal mold could be successfully used for curing of acrylic denture base material by microwave irradiation with physical properties (transverse strength, porosity) similar to that cured by conventional water bath technique.

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