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Original Research Article

Effect of Conventional Polishing Procedure in Water Sorption of Cold and Heat Cured Acrylic Denture Base Material

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Abstract

Acrylic resin is almost universally for partial or complete denture base construction due to its favorable properties. Unfortunately some disadvantages such as water sorption have been reported which causes dimensional changes that may subject the acrylic denture base to internal stresses, so the water sorption is a physical property of importance. Forty square shaped specimens (twenty specimens for heat and cold cured acrylic material) were prepared. Ten specimens from heat cured acrylic (H_P) and cold cured acrylic (C_P) material were polished, and ten specimens from heat cured acrylic (H_x) and cold cured acrylic (C_x) were not polished as control group. At room temperature, all specimens were weighed; this weight value was considered the initial weight of the specimen (W_0). All specimens were kept in distilled water bath for 24 hours, and then specimens were weighed(W_1)then the specimens were kept out of water bath for 24 hours to dry to (W_0), and all samples return back to water bath for 24 hours to weigh again (W_2). This manner was repeated till (W_4).There is a significant difference ($p=0.018$) between (C_P) and (C_x) and a significant difference ($p=0.047$) between (H_P) and (H_x) and no significant difference between cold and heat cured acrylic before ($p=0.699$) and after polishing ($p=0.52$) at ($p \leq 0.05$).

Key words: heat cured acrylic, cold cured acrylic, water sorption, polishing.

الخلاصة

يعتبر راتنج الأكريليك المستخدم غالبا لبناء قاعدة أسنان الطقم الجزئي أو الكامل وذلك بسبب خصائصه الجيدة ولكن تم تعيين بعض العيوب مثلا لامتصاص للمياه والذي يسبب تغيرات في الأبعاد التي قد تعرض قاعدة الأسنان المصنوعة من الاكريليك إلى الضغوط الداخلية، لذا فأن خاصية أمتصاص الماء تعتبر من الخواص المهمة. أعدت أربعون عينة على شكل مربع (عشرون عينة من الراتنج الأكريليك المتبلمر بالحرارة وعشرون من الراتنج الأكريليك ذاتي التبلمر). عشرة عينات من الراتنج الأكريليك المتبلمر بالحرارة وعشرة عينات من الراتنج الأكريليك ذاتي التبلمر تم صقلها وتلميعها.) . عشرة عينات من الراتنج الأكريليك المتبلمر بالحرارة وعشرة عينات من الراتنج الأكريليك ذاتي التبلمر لم تصقل كي تبقى كمجموعة تحكم. كل العينات تم وزنها في درجة حرارة الغرفة واعتبر هذا هو الوزن الاولي (الوزن صفر). تم حفظ كل العينات في حمام من الماء المقطر لمدة 24 ساعة وبدرجة حرارة الغرفة وتم وزنها وهو (الوزن1) ثم أخرجت العينات من حمام الماء وبقيت لتجف لمدة 24 ساعة حتى رجعت (للوزن صفر). بعدها تم أعادة العينات للحمام المائي ولمدة 24 ساعة وهو (الوزن2) تم أعادة هذه العملية حتى (الوزن4). أظهرت النتائج تغير معنوي بين الراتنج الأكريليك ذاتي التبلمر المصقول وغير المصقول, وتغير معنوي بين الراتنج الأكريليك المتبلمر بالحرارة المصقول وغير المصقول, ولم يكن هناك اختلاف معنوي بين الراتنج الأكريليك ذاتي التبلمر و الراتنج الأكريليك المتبلمر بالحرارة لا قبل ولا بعد عملية الصقل.

الكلمات المفتاحية: الراتنج الأكريليك المتبلمر بالحرارة, الراتنج الأكريليك ذاتي التبلمر , أمتصاص الماء, الصقل.

Introduction

Polymethyl methacrylate resin is almost universally for partial or complete denture base construction due to its favorable properties of matching the appearance of the natural oral soft tissues, ability to reline, rebase and repair and simple processing technique and dimensional stability [1]. Polymethyl methacrylate resin denture base has dominated the market for more than 70 years in substitution of vulcanite [2].

Conversely some disadvantages such as water absorption have been reported which causes dimensional changes, which may subject the acrylic denture base to internal stresses that may result in surface crazing and, eventually, fractures of the denture [3,4],also the water sorption may sustain the growth of bacteria or fungi [5].

Water sorption is a physical and chemical process by which incorporation and adherence and adherence of water molecules into another of a different state (acrylic resin material) [6]. According to ISO standards (International Standards Organization) 1567:1999 for heat and self-cured acrylic resin materials; the water sorption should not exceed 32 μg/mm^3[2]. In this study the water sorption was calculated according to this specification.

During polishing method it is very important to removefine scratches; to make the acrylic denture more smoothly and glossy without making a difference in the original shape [7]. There are many advantages of polishing like aiding in esthetic, hygienic role, and comfortable to patient, and because of the major role of water uptake and sorption in the mechanical performance of an acrylic material that affect the clinical outcome, many studies on the water sorption of acrylic resin denture base materials have been concluded that sorbed water may cause the deterioration of the mechanical properties [4,8,9,10], because of water molecules incorporate into and expand the polymethyl methacrylate macromolecules and forcing them apart [11], so the water molecules incorporation in the denture base should be as low as possible [12].

This study was done to evaluate the effect of conventional polishing procedure in decreasing water sorption and consequently the undesirable effects on the heat and cold cured acrylics. The hypothesis was that water sorption of the cold and heat cured acrylic resins, is affected by the polishing procedure.

Materials and Methods

40 specimens were prepared (20 specimens for each heat and cold cured acrylic resin denture base material). 10 specimens from heat cured acrylic (H_P) and cold cured acrylic (C_P) material were polished by conventional manner, and ten specimens from heat cured acrylic (H_x) and cold cured acrylic (C_x) were not polished as control group.

A plastic pattern square shaped, with dimensions (4×30×30 mm) were used to prepare the mold which was used to prepare the specimen.

The plastic patterns were inserted in the lower half of flask, care was taken that only one half of the pattern thickness was embedded in the stone, where the plastic patterns were placed, there should be a sufficient distance between them and also from the walls of the flask. After setting of the stone the patterns and the stone were painted with separating medium and the upper part of the flask was then reassembled and complete flasking by pouring another mixture of stone. After complete setting of the second mix of stone, the flask was opened and the plastic patterns were removed carefully, and the stone molds were ready for packing.

A Vertex® cross-linked commercially acrylic material was used, with polymer/monomer in ratio of 2.3g/1ml according to manufacturer's instructions, was mixed thoroughly. Once the mixture reached the dough stage, it was kneaded thoroughly to

make homogeneous dough. The dough was then packed into the mold with slow pressure, final closure was done under a hydraulic press at (100 KPs/cm²) to ensure even flow of the material within the mold. After the final closure, the flask was left in the clamp for half hour at room temperature to allow proper penetration of the monomer into the polymer beads, and escape of excess acrylic [13].

The cold cured specimens allow to self-cure while the heat cured specimens was processed, by short curing cycle, according to ADA specification No.12: 1999 for curing acrylic denture base material; by placing the clamped flask in74ºC water bath for 1.5 hour followed by 100ºC water bath for half hour. The flask was left on bench to cool slowly before deflasking, and then the specimens were removed from the mold. Any specimens had faults or defects should be discarded.

All specimens were finished, any excess acrylic was removed from the processed denture by the use of stone wheel burs. Care was taken not to heat the denture during grinding, because this may cause distortion of the specimens.

Only 20 specimens (ten heat and ten cold cured specimens) were polished as usual manner that used for polishing of acrylic removable prosthesis by using progressively smoother aluminum oxide papers (Atlas, Turkey) a rag wheel with pumice (Qingzhao, China) is used for polishing the specimens. Then a final high polish is given to the denture with a rag wheel and Rouge polishing material (Ningbo, China).

At room temperature, all specimens were weighed on digital scale (Model DM.3, China); this weight value was considered the preliminary weight (W_0) of the specimen. The specimens were weighed after maintained in distilled water bath at room temperature for 24 hours; this wasconsidered (W_1). After that the specimens were dried by removing from the water bath, wiped and kept out of water for 24 hours, until the initial weight was achieved. Again all specimens return back to water bath for 24 hours and weighed (W_2). This manner was repeated till (W_4).

The values for water sorption (W_{sp})for each of the specimens, was calculated using the following equation; which is recommended by International Standards Organization which depends on increasing in mass per unit volume [14].

$$W_{sp} = \frac{W_{(from\ 1\ to\ 4)} - W_0}{volume} \mu g/mm^3$$

Statistical Package for Social Sciences computer program (SPSS) was used to analyze the data of this study. The mean values of the W_{sp} properties evaluated using t-test (2-tailed) to detect the differences of the mean values of the materials.

Results

Descriptive statistics (table 1 and 2 and 5) reveal a clear difference between the mean of the (H_p) and (H_x), while analytics statistics that representative by t-test (2-tailed) between different experimental groups (table 6) indicates a significant difference (p=0.047) between polished and unpolished heat cured acrylic at ($p \leq 0.05$).

There are clear difference between the mean of the (C_p) and (C_x) (table 3 and 4 and 5), while t-test (2-tailed) between different experimental groups (table 6) indicates a significant difference (p=0.018) between polished and unpolished cold cured acrylic at ($p \leq 0.05$).

In (table 1 and 2 and 5) there were very small difference between the mean of the (C_x) and (H_x), and the t-test (2-tailed) indicates no significant difference (p=0.699) between unpolished cold and heat cured acrylic at ($p \leq 0.05$); (table 7).

The results(in table 2 and 4 and 5) indicate small difference between the mean of the (C_p) and (H_p); and the t-test (2-tailed) indicates no significant difference between polished cold and heat cured acrylic at ($p \leq 0.05$); (table 7).

Table 1 : Descriptive statistics of unpolished heat cured acrylic (H_x); four readings and the mean of W_{sp}.

Unpolished heat cured acrylic (H_x)				
W_{sp1}	W_{sp2}	W_{sp3}	W_{sp4}	Mean of W_{sp}
9	14	16	13	13
7	8	8	6	7.25
10	13	15	7	11.25
12	9	11	11	10.5
8	8	16	9	10.25
11	14	16	13	13.5
8	8	16	8	10
1	8	8	6	8
12	11	9	10	10.5
9	13	15	7	11

Table 2 : Descriptive statistics of polished heat cured acrylic (H_p); four readings and the mean of W_{sp}.

Polished heat cured acrylic (H_p)				
W_{sp1}	W_{sp2}	W_{sp3}	W_{sp4}	Mean of W_{sp}
6	7	9	11	8.25
9	7	9	10	8.75
9	10	9	7	8.75
7	10	8	10	8.75
8	10	8	9	8.75
6	7	9	11	8.25
11	9	10	9	9.75
8	10	7	10	8.75
10	7	9	10	9
8	13	9	6	9

Table 3 : Descriptive statistics of unpolished cold cured acrylic (C_x); four readings and the mean of W_{sp}.

Unpolished cold cured acrylic (C_x)				
W_{sp1}	W_{sp2}	W_{sp3}	W_{sp4}	Mean of W_{sp}
7	8	13	7	8.75
14	12	10	7	10.75
11	13	13	9	11.5
7	12	11	13	10.75
13	11	11	9	11
13	12	13	13	12.75
14	11	15	9	12.25
13	11	11	8	10.75
7	9	8	10	8.5
12	11	11	14	12

Table 4 : Descriptive statistics of polished heat cured acrylic (C_x); four readings and the mean of W_{sp}.

Polished cold cured acrylic (C_p)				
W_{sp1}	W_{sp2}	W_{sp3}	W_{sp4}	Mean of W_{sp}
7	12	7	6	8
10	11	11	10	10.5
10	10	8	9	9.25
7	11	10	10	9.5
7	13	10	11	10.25
7	8	10	9	8.5
10	9	11	11	10.25
8	9	7	8	8
7	10	10	10	9.25
7	9	8	8	8

Table 5 : Descriptive statistics of all experimental groups

	unpolished cold cured	polished cold cured	unpolished heat cured	polished heat cured
	8.75	8	13	8.25
	10.75	10.5	7.25	8.75
	11.5	9.25	11.25	8.75
	10.75	9.5	10.5	8.75
	11	10.25	10.25	8.75
	12.75	8.5	13.5	8.25
	12.25	10.25	10	9.75
	10.75	8	8	8.75
	8.5	9.25	10.5	9
	12	8	11	9
Mean	10.9	9.15	10.525	8.8
Calculated t	2.667		2.181	

Table 6 : Descriptive statistics (mean and standard deviation); and analytics statistics(t-test) between unpolished and polished cold cured acrylic; unpolished and polished heat cured acrylic

	Mean ±SD	P(2-tailed)
Unpolished cold cured acrylic	10.9±1.38	0.018
Polished cold cured acrylic	9.15±0.98	
Unpolished heat cured acrylic	10.52±1.92	0.047
Polished heat cured acrylic	8.8±0.42	

Table 7 : Descriptive statistics (mean and standard deviation); and analytics statistics (t-test) between unpolished cold and heat cured acrylic; polished cold and heat cured acrylic

	Mean ±SD	P(2-tailed)
Unpolished cold cured acrylic	10.9±1.38	0.699
Unpolished heat cured acrylic	10.52±1.92	
Polished cold cured acrylic	9.15±0.98	0.52
Polished heat cured acrylic	8.8±0.42	

Discussion

On the basis of these data, the hypothesis set as the premise of this study should be accepted. The polishing procedure decreases the water sorption of the cold and heat cured acrylic resins this occur because benefit of polishing process which increased toughness, and decrease the permeability of the surface layer of the acrylic, this is due to local heating generates during polishing process. The local rise in temperature often exceed the glass transition temperature (*Tg*) of the acrylic, producing some smearing of the resin surface which act like varnish that decreases the polarity of acrylic by minimizing the concentration of polar sites available to form hydrogen bonds with water molecules [2,15,16]. Arima et al concluded the chemical structure of the acrylic versus that of the water molecule significantly affected the water sorption of acrylic. The unsaturated bonds of the acrylic molecules or unbalanced intermolecular forces in the acrylic increase the polarity of acrylic molecules which increase the uptake of water molecules [17].

The surface area of rough acrylic specimen is more than that of polished one, that lead to increase the interface area between the water molecules and the acrylic, so the acrylic is exposed to more water molecules in rough specimen than polished specimen, that lead to more water adsorption[6]

Polishing procedures may influence surface smoothness, and rough surfaces mechanically retain moisture more than smooth surface [18,19].

The difference between the initial contact angle and the later angle formed between water drops and acrylic which is used to analyze the relation of acrylic to water [20] is called hysteresis of contact angle. The contact angle hysteresis on the rough surface is lowered than on polished surface. The lower angles, the more hydrophilic surface [21] that mean the water entrance in rough

acrylic increases its hydrophilic characteristic [22,23].

Usually the water uptake of cold cured acrylic is more than that of heat cured acrylic, which is due to its residual monomer and porosity that could affect water sorption [24], the high amount of porosity will facilitate fluid transport in and out of the network, leading to enhanced water uptake and elution [15]. During the preparation of cold cured specimen, the dough was then packed into the mold with slow pressure under a hydraulic press at (100 KPs/cm²) to preclude other factors that affect the water sorption like porosity and let only the surface polishing as a main factor to be calculated during this study, so the result appears no significant difference between polished and unpolished heat and cold cured acrylic due to this pressure applied on cold cured acrylic specimen that increase the density and decrease the porosity.

Miettinen and Vallittu [14] reported that degree of chain branching and presence of cross-linking agent has influence on resin water sorption degree; the cold cured resin was used in this study is cross-linked type; the more cross-linked acrylic, the less amount of water sorption [11], because the cross-linked acrylic have formatting more tight, complex and interlaced chains, so less volume of interstitial matrix, less volume for water molecule penetration[25]. It does not give the opportunity for water molecules to enter in quantity and velocity as great as uncross-linked one.

The present study has several limitations;the specimen surfaces were flat, whereas, clinically, the denture base has an irregular shape with convex and concave surfaces, and the conditions of water bath did not reflect the clinical situations exactly.

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