Atatürk Üniv. Diş Hek. Fak. Derg.
J Dent Fac Atatürk Uni
Cilt:21, Sayı: 2, Yıl: 2013, Sayfa: 214-219

Araştırma/ Research Article

THE EFFECT OF DIFFERENT POLYMERIZATION PERIODS ON WATER SORPTION OF ACRYLIC RESINS

FARKLI POLİMERİZASYON SÜRELERİNİN AKRİLİK REZİNLERİN SU EMİLİMİ ÜZERİNE ETKİSİ

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Makale Kodu/Article code: 965
Makale Gönderilme tarihi: 12.11.2012
Kabul Tarihi: 27.06.2013

ABSTRACT

Purpose: The purpose of this study was to compare the water sorption of four different heat-polymerized acrylic resins which polymerized in a regular time and a period of two times the normal range.
Material and Methods: Heat-polymerized acrylic resins are QC-20, Vertex, Meliodent and Paladent-20. Water sorption was measured after 1 day, 1 week and 1 month. Water sorption analyzed with two-way analysis of variance (ANOVA) and Duncan test.
Results: The results indicated that the values of water sorption for 1 week and 1 month was observed a significant difference between the groups. (p<0.01) The values of water sorption for the samples much polymerized, was significantly high.
Conclusion: Different heat-polymerized acrylic resins showed different water sorption in case of polymerized in a regular time and a period of two times the normal range.
Key words: Acrylic resin, Water sorption, Polymerization

ÖZET

Amaç: Bu çalışmanın amacı normal sürede ve normal sürenin iki katı sürede polimerize edilen dört farklı sıcak akrilik rezinde su emilimini değerlendirmektir.
Gereç ve Yöntem: Sıcak akrilik rezinler QC-20, Vertex, Meliodent ve Paladent-20' dir. Su emilimleri 1 gün, 1 hafta ve 1 ay sonra değerlendirildi. Su emilim değerleri iki-yönlü varyans analizi ve Duncan testi ile analiz edildi.
Bulgular: Sonuçlar 1 hafta ve 1 aylık su emilim değerleri gruplar arasında önemli farklılıklar göstermiştir.
(p<0.01) Fazla polimerize edilen örneklerde su emilim değerleri önemli derecede fazladır.
Sonuç: Normal sürede ve normal sürenin iki katı sürede polimerize edilen farklı sıcak akrilik rezinler farklı su emilim değerleri göstermiştir.
Anahtar kelimeler: Akrilik rezin, Su emilimi, Polimerizasyon

INTRODUCTION

Acrylic resin is the most employed material in partial removable or complete denture bases. This material began to be used in the 1930s in substitution of vulca- nite. Polymethylmethacrylate is the most used acrylic resins. Polymethylmethacrylate is characterized as being strong, copying oral tissue appearance, showing low water sorption and solubility and having good dimensional stability.[1]

Water sorption being counted among the physical properties of acrylic resin is significantly

Water sorption being counted among the physical properties of acrylic resin is significantly important case related to dimensional change. Low water sorption for prosthesis base resins, is important in terms of compensate of the contractions that may be occurred on base of prosthesis. Water sorption attributes to the polar features of the resin molecules and according to the rules of diffusion it can be explained by the diffusion of water molecules.[2-5] It is explained that diffusion forced the resin molecules go away from each other. Namely, water molecules go away resin molecules from each other by penetrating

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among them and thus, there would be an expansion in size.[2,3,5-7] In this regard, water helps to relax of stresses in acrylic resins.[5,6]

Polymethylmethacrylate absorbs water slowly in long term.[8] The water absorbed into the material acts as a plasticizer and decreases the mechanical properties such as hardness[9] , transverse strength[10] and fatigue limit.[11] In acrylic resins which water absorbed, an linar expansion with 23% rate is appeared as a result of 1% of weight increase.[12,13]

Some researchers claim that dimensional changes as a result of water absorption, are effective on retention and stability of the prostheses and the wetness is a desired feature to increase retention of the prostheses.[14,15] Whereas, some researchers said that there was a relate between high water sorption and clinical failure in the prosthesis base materials when investigated in previous years.[16]

Dimensional change occurred on prosthesis as a result of water absorption of acrylic, is an alternately event**.** If the prosthesis is left in open air and a dry place, it allows water to left its structure and undergoes contraction. Therefore, for patients using removable prosthesis, it is recommended that hold the prosthesis in water during that it is not used.[17]

Currently, the most widely used method of acrylic resin polymerization; is polymerizing of a mass of acrylic resin reacted flasks by heating in a water bath. In this classical method, the process of boiling is applied by two ways as rapid and slow boiling. [18,19-24] If this process is applied in a short time and at high temperature, residual monomer becomes more. Residual monomer is free monomer being unreacted in acrylic. If residual monomer becomes more, it creates allergic reactions in tissues and gets the structure of the prosthesis weakened.[25,26]

Residual monomer is a free monomer that was unreacted in acrylic resin. At the beginning of polymerization of acrylic resin, firstly the amount of monomer in mass decreases rapidly, but this speed slows later. Studies showed that at the end of a long-term polymerization method, the amount of residual monomer was lower than 0.4%. Polymerization of acrylic resins for a long-time and finally, keeping the flasks in a boiling water for a few hours provide a decrease at minimal levels for rest of monomer. But in mass, there is always a few amount of monomer. According to the different methods of polymerization, the amount of residual monomer changes.[26]

The purpose of our study is investigating whether much polymerized of hot acrylic resins than normal has an effect on the amount of water sorption or not.

MATERIALS AND METHODS

In our study, 4 different heat-polymerized acrylic resins were used. Heat-polymerized acrylic resins used, are shown in Table 1.

Table 1. Heat-polymerized acrylic resins

	Material	**Manufacturer**
1.	De Trey QC-20	Dentsply De Trey, Brasil
2.	Meliodent	Heraeus Kulzer, Wehrheim / TS
3.	Vertex	Dentimex B.V., Netherland
4.	Paladent 20	Heraeus Kulzer, Germany

Specimen discs were prepared in accordance with ADA (American Dental Association) Specification No. 12.[27] To obtain test samples, firstly the samples with 50 ±1 mm in diameter and 0.5±0.01 mm thick from stainless steel have been prepared. Samples prepared from stainless steel, were taken to flask by using routine methods. Acrylic material prepared by adjusting the rate of liquid/powder in accordance with the recommendations of the manufacturer of each brand acrylic, was reacted for the spaces occurred in flask. 10 samples obtained from each brand acrylic by polymerized in a regular time and also 10 samples obtained by polymerized a period of two times the normal range, totally 20 samples were obtained. As a result, a total of 80 specimens were obtained from 4 different heat-polymerized acrylic resin.

After the process of finish and polishing was completed, the prepared samples of all acrylic were stored in a desiccator containing thoroughly dry silica gel at 37±2°C for 24 hour.

After the samples were removed from desiccators, their first weights were recorded by using an analytical balance of 0.1 mg precision. The acrylic samples were stored in distilled water at a temperature of 37±2°C for 1 day. After 1 day, the samples were completely dried with a clean towel, their weights were recorded. Recorded acrylic samples were stored in distilled water at a temperature of 37±2°C for 6 day. Then, they were dried with a clean towel, their weights were recorded to determine water absorption for 1-week. To determine water sorption for 1-month, the samples were stored in distilled water at a temperature of 37±2°C for 23 days. After a while, they were dried dried with a clean towel and their last weights were recorded.

To determine the water sorption occurred on acrylic samples, the formulas shown below were used:

Water absorption (1 day) = $M_2 - M_1 / S$
Water absorption (1 week) = $M_3 - M_1 / S$
Water absorption (1 month) = $M_4 - M_1 / S$

M_1 = Initial weight of samples kept in desiccators (mg)

M_2 = Weight of samples that were kept in distilled water for 1 day (mg)

M_3 = Weight of samples that were kept in distilled water for 1 week (mg)

M_4 = Weight of samples that were kept in distilled water for 1 month (mg)

S = Surface area of the samples (cm^2)

RESULTS

SPSS 17.0 was used to obtain statistical results of our study. The values of mean and standard deviation belonged to the samples, have been shown in Table 2.

In QC-20 and Meliodent, the values of water sorption, at the end of 1st day, are higher for the samples boiled in a regular time. While the values of water sorption in Paladent-20 are higher, in Vertex the values of water sorption in each group are almost similar. At the end of 1st day, while the value of maximum water sorption was observed on the group of QC-20 that was boiled in a regular time; the value of minimum water sorption was observed on the group of Paladent-20 that was boiled in a regular time. After 1 month, while the value of maximum water sorption was observed again on the group of QC-20 that was boiled in a regular time; the value of minimum water sorption was observed on the group of Vertex that was boiled in a regular time.

When the values of water sorption are observed according to the times, it shows a significant increase on the values of all samples during the period of 1st day to 1 week. At the period of 1st week to 1 month, Although the values of water absorption are not as much as at the 1st period, it still shows an increase.

Whether there is a difference or not between the groups boiled on regular time and much time, was assessed with two-ways analysis of variance (Table 3). At the end of analysis: while it was not observed a difference between the groups with respect to the values of water sorption at the end of 1st day, on the values of water sorption for 1 week and 1 month, it was observed a significant difference between the groups ($p<0.01$). The values of water sorption for the samples much boiled, was significantly more. According to the brands, interaction (brand*group) was not importance with respect to the groups.

Duncan test was used for the multiple comparison of means. When the results of Duncan test that belong to the values of 1st day water sorption are observed (Table 4); it is not seen a significant difference among the brands. While Paladent-20 has less value of water sorption than the other brands; QC-20 has the most excessive value of water sorption with a low difference from Meliodent.

When Duncan test results-belonged to the values of water sorption for 1 week are observed (Table 5); there is not significant difference among the brands. Vertex and Paladent-20 are located in the same group and they have the same values of water sorption. The most excessive value of water sorption belongs to QC-20.

When Duncan test results-belonged to the values of water sorption for 1 week are observed (Table 6); there is not significant difference among the brands. Vertex-Meliodent and Paladent-20 and QC -20 are located in the same group. The lowest value of water sorption is for Vertex on the other hand, the most excessive value of water sorption is for QC-20.

Table 2. Mean and standard deviation of the samples' water sorption

		Water sorption of 1st day	Water sorption for 1 week	Water sorption for 1 month
Brand	**Group**	**Mean ± Standart Deviation**	**Mean ± Standart Deviation**	**Mean ± Standart Deviation**
QC-20	**1**	0.2220 ± (0,0047)	0.4848 ± (0.0081)	0.5450 ± (0.0172)
	2	0.2175 ± (0.0054)	0.5047 ± (0.0058)	0.5780 ± (0.0152)
Meliodent	**1**	0.2170 ± (0.0082)	0.4685 ± (0.0130)	0.5152 ± (0.0208)
	2	0.2157 ± (0.0067)	0.4816 ± (0.0096)	0.5494 ± (0.0208)
Vertex	**1**	0.2123 ± (0.0049)	0.4484 ± (0.0085)	0.4970 ± (0.0188)
	2	0.2122 ± (0.0085)	0.4702 ± (0.0203)	0.5317 ± (0.0462)
Paladent 20	**1**	0.1884 ± (0.0106)	0.4483 ± (0.0128)	0.5297 ± (0.0217)
	2	0.2035 ± (0.0069)	0.4707 ± (0.0097)	0.5489 ± (0.0423)

1: The samples - polymerized on regular time
2: The samples - polymerized on much time.

Table 3. Two-way analysis of variance results

		Total square	df	Mean square	F	Sig.
Brand	Water sorption of 1st day	0.007	3	0.002	42.236	0.000
	Water sorption for 1 week	0.017	3	0.006	40.853	0.000
	Water sorption for 1 month	0.023	3	0.008	9.922	0.000
Group	Water sorption of 1st day	0.000	1	0.000	2.003	0.161
	Water sorption for 1 week	0.007	1	0.007	54.059	0.000
	Water sorption for 1 month	0.018	1	0.018	23.848	0.000
Brand* Group	Water sorption of 1st day	0.001	3	0.000	7.287	0.000
	Water sorption for 1 week	0.000	3		0.669	0.574
	Water sorption for 1 month	0.001	3	0.000	0.363	0.780

p<0.01

Table 4. Duncan test results-belonged to the water sorption of 1st day.

	N	1	2	3
Paladent-20	20	0.1960		
Vertex	20		0.2122	
Meliodent	20		0.2163	0.2163
QC-20	20			0.2198
Sig.		1.000	0.082	0.138

Table 5. Duncan test results-belonged to the water sorption for 1 week

	N	**1**	**2**	**3**
Vertex	20	0.4593		
Paladent-20	20	0.4595		
Meliodent	20		0.4751	
QC-20	20			0.4948
Sig.		0.959	1.000	1.000

Table 6. Duncan test results-belonged to the water sorption for 1 month

	N	**1**	**2**	**3**
Vertex	20	0.5143		
Meliodent	20	0.5323	0.5323	
Paladent-20	20		0.5393	0.5393
QC-20	20			0.5615
Sig.		0.044	0.426	0.013

DISCUSSION

It was proved that acrylic resins, being used as material of prosthesis base have the value of water sorption in specific proportions. However, it was stated that, they were considered clinically insignificant in terms of fitting these values for standards.[12,16,18] The same type of prosthesis base resins modified with some additives, exhibits different value of water sorption. The thickness of test sample and the type of polymer is very effective on the amount of water sorption for 24 hours.[5,7,28] It was stated that value of water sorbtion for prosthesis base resins must not be more than 0.7 mg/cm^2 according to the ADA standards.[27] Anderson reported that the value of water sorption is 0.5-0.6 mg/cm^2.[5]

Philips stated that the same value should not be more than 0.8 mg/cm^2. Craig *et al*. reported that the value of water sorption should be around 0.6 mg/cm^2 at heat-polymerized acrylics, but the value of water sorption for acrylics-used routine, shows variability between 0.6-0.9 mg/cm^2.[5,18]

The values of water sorption that were obtained as a result of our study, is consistent with ADA standards and the values of water sorption that was mentioned by researchers-above.

In general, acrylic resins with incomplete polymerization cannot interact with media during polymerization because of using all reactive substances.[29] Furthermore, polymer molecules have very little capability of passing from the layers of epidermal and being diffused because of their sizes. This is mainly acceptable for large monomer molecules, too. With the increase of molecular size, a decreasing occurs on capability of motion. Relatively, while small molecule of methyl methacrylate is quite active, it can be mentioned that the large size of molecules known as Bowen's molecule, have less allergic potential.[30]

Dogan et al.[31] studied the effects of varying polymerization times and temperatures on the residual monomer content of polymer/monomerbased denture base materials. The authors showed that increased temperatures and extended polymerization times were accompanied by a decrease in the residual monomer content.

The reaction products and residual monomers that are present in the polymer structure just move towards to surface and interact with organism when they reach the surface. Thus, only the substances being on the surface are biologically important.[32] To reduce the amount of these substances in acrylic resin, it needs to keep in water for a long-time. In this way, the substances with low molecular weight in other words more reactive substances- pass to water.[33] Consequently, this substances cannot solute in patient's mouth and in this way, the amount of potential allergen reduce. The concentration of residual monomer can reduce with a good process of polymerization. For that reason, it is required sufficient temperature and more time as much as possible.[32]

In our study, with above-mentioned situations, we can explain that samples of acrylic resin-polymerized highly, absorb much water than the other ones. To reduce the amount of residual monomer in acrylic resin, residual monomers pass into the water at the end of processes with boiling much and keeping in water for a long time. Therefore, water molecules fill the space occurred on the structure of acrylic resin by diffusing. Thus, they have much more value of water sorption. Jagger[33] reported a correlation between residual monomer and water sorption. If residual monomer is present, less monomer conversion occurs and may result in increased sorption.[34,35]

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