THE EFFECT OF TWO CURING PROCESSING TIME BY IVOMAT ON THE POROSITY OF COLD CURE ACRYLIC RESIN DENTURE BASE (A COMPARATIVE STUDY)

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الملخص

تهدف هذه الدراسة إلى تقييم تأثير المعالجة بواسطة الماء والضغط الحراري داخل جهاز الـ Ivomat على مسامية قاعدة طقم الأسنان المصنوع من راتنجات الاكريليك الباردة في مركز و محيط العينات المتبلمرة لمدة (15 و 20 دقيقة) و مقارنتها مع راتنجات الاكريليك الباردة المتبلمرة بصورة ذاتية (كيميائيا). تم استخدام 30 عينة من راتنجات الاكريليك الباردة ذات الأبعاد (65* 62* 64* 61 ملم) و سُمك (3 ملم),كما و قسمت إلى 3 مجاميع تجريبية (العـــدد = 10 لكـل مجموعـــة تجريبيـة)

(راتنجات الاكريليك البـــــاردة: بلـــمرة ذاتيـة- 45 دقـيقة/ مجموعة ضـابطة : G1)

(راتنجات الاكريليك البـــــاردة: معالـج مائي تحت ضغط حـــراري- 15 دقـيقة : G2)

(راتنجات الاكريليك البـــــاردة: معالـج مائي تحت ضغط حـــراري- 20 دقـيقة : G3)

لـــقد تـم تقييم المسامية لـلعينات بعد إكمال المعالجـة, التـشذيب, و التلميع, بـعد ذلـك أغمرت العينـات في حبر اسود وأحصيت المســـام بواسطة المجهر. أظهرت النتائج بصورة عامة أن راتنجات الاكريليك الباردة المتبلمرة داخل المعالج المائي و تـحت الضغط الحـــراري لمدة 15 و 20 دقـيقة مستوى مسامية اقـل عند محيطات العينة منه عند المركـز, كـما وان راتنجات الاكريليك الباردة المتبلمرة داخل المعالج المائي و تـحت الضغط الحـــراري لمدة 15 دقـيقة يملك مسامية أعلى من راتنجات الاكريليك الباردة المتبلمرة لمدة 20 دقـيقة بالرغم من استخدام نفس المعالج, بينمـا أظهرت راتنجات الاكريليك الباردة و المتبلمرة داخل المعالج المائي و تـحت الضغط الحـــراري إنها تملك اقل نسبة مسامية عن راتنجات الاكريليك المتبلمرة بصورة ذاتية تحت الضاغط الهيدروليكي.

ABSTRACT:

This study aimed at assessing the effect of two times curing by Ivomat on the porosity of cold cured acrylic resin denture base at the center and the periphery of the specimens for (15) and (20) minutes, and comparing that with cold cured acrylic resin polymerized chemically on air (Control group). 30 samples specimens of (65 x 62 x 64 x 61 mm), with (3 mm) thickness according to (ADA specification No.12) . There were 3 experimental groups, (n = 10 per group): G1) cold cure acrylic resin (chemical curing- 45 minutes) as a control group; G2) cold cure acrylic resin (Ivomat curing technique- 15 minutes); G3) cold cure acrylic resin (Ivomat curing technique- 20 minutes). The porosity test was assessed after specimens were completely cured, finished and polished, and then immersed in black ink and the pores counted in a microscope. Generally the results revealed that the cold cure acrylic specimens which processed in Ivomate for (15) and (20) minutes introduced less porosity level in the periphery than that of the center, and the cold cure acrylic specimens which processed in Ivomate for (15 minutes) have porosity level more than cold cure acrylic which polymerized for (20 minutes) in spite of the same processing technique, while the cold cure acrylic specimens which processed in Ivomate showed less level of porosity than that cold cure acrylic polymerized chemically on air and under hydraulic press.

Introduction: Acrylic resin denture base is an indispensable material in removable orthodontics and prosthodontics. Acrylic plastic have been the most widely used and accepted among all denture base materials and it was estimated that they represent 95% of the plastics in prosthodontics [1, 2].

The acrylic resins success as denture base and still remains the most popular choice are due to its excellent esthetic properties, adequate strength, low water absorption, low solubility, free from toxicity, can be easily repaired, has the ability to reproduce accurately and retain indefinitely the details and dimensions of a pattern [3, 4], in addition it required simple processing equipment and relatively low cost of fabrication process [5, 6].

Initiation of polymerization of acrylic resin can be accomplished by heat activated, chemical, microwaves, and visible light activation. Acrylic dentures base resins and their curing processes have been modified not only to improve physical and mechanical properties but also to improve working properties [7, 8]. Although, widely used as a denture base material, acrylic resin exhibits certain poor mechanical properties where fractures may occur both outside or inside the mouth [2]. Denture base acrylic resin is subjected to many different types of stress, intra- orally, repeated masticatory force lead to fatigue phenomena, while extra- orally high impact forces may occur as a result of dropping the prosthesis [9].

The polymerization reaction of cold cure acrylic resin almost as soon as the powder and liquid are mixed and proceed more rapidly, through the various consistency stages than the heat activated type, hence, the chief problem with the cold cured resin is the short working time for adequate trial packing [10], so the degree of polymerization of cold cure acrylic resin is not as complete as that achieved by using heat cured system, this leads to higher degree of residual monomer [1, 11] .

One of the most important physical properties that can be noticeable in the acrylic resin denture base material is the porosity which is appear like voids, pores, or micro cracks that developed during the polymerization of the resin causing weakness in the final product, with a degrease in the values of their mechanical properties. Therefore the presence of porosity in the acrylic resin after curing process , and it is also found after many years of the use PMMA as a denture base material, porosity is apparently a complex phenomenon with multifactor origin [10] .

Some authors concluded that the porosity may result from lack of homogenously in the dough or get at the time of polymerization would cause porosity in acrylic [12], and insufficient pressure that distributed uniformly through out the material [2], while some of them showed that the minimizing and absence of porosity of the acrylic denture base resin will not be under normal circumstance [13], and heat generation is so great that it can boil unreacted monomers creating porosity in the final polymer; therefore steps must be taken to avoid this porosity [12]. So this study was designed to evaluate the effect of two curing processing times for (15) and (20) minutes by Ivomat curing device on the porosity of cold cure acrylic resin material and also at both the periphery and the center of acrylic specimens samples.

MATERIAL AND METHODS

Metal pattern

Semi square stainless steel plate with dimensions of (65 x 62 x 64 x 61 mm), with (2.5± 0.5 mm) thickness according to (ADA specification No.12) [14] were constructed for porosity analysis to save time and effort. The pattern was included in metal flask, the lower half of each flask was completely filled with type III dental stone (Elite model, Italy) whose surface was flattened with 320 and 400μm silicon carbide paper discs (Germany) after the setting reaction.

Mixing and packing of acrylic

Pink cold cured acrylic resin (Italy) was used to fabricate the samples in this study, following the manufacturer's instructions of powder/ liquid ratio by volume. the cold-cured acrylic was (2.5:1) by volume, and then left to reach the dough phase at room temperature (approximately 23°C). After filling the mold with the dough, the flasks were fitted and pressed together in a hydraulic bench press for (5) minutes before polymerization process.

Curing of acrylic

Curing was carried out by placing the clamped flask in Ivomat curing device (Germany), Figure (1). This device was used when containing water under air pressure (4 bar) for (15) minutes once and (20) minutes for another at constant water temperature of (50 Cº) followed by complete cooling of the flask with tap water for (5) minutes before deflasking, While in case of chemically polymerized cold cure acrylic resin, flasks containing the acrylic resin dough were left in a bench under hydraulic press (Germany) for (45 minutes) at (23Cº ± 5Cº) under (60 PSI= 4bar) air pressure as a control group [15]. The acrylic patterns were then removed from the mold.

Figure (1): Ivomat curing device

Finishing and polishing

All flashes of acrylic were removed with acrylic bur (Germany), to get a smooth surface , the stone bur (Germany) should be used followed by (120) grain size sand paper (Germany) to remove any remaining small scratches with continuous water cooling. In order to prepare a specimen for optical microscopy, the specimens were reduced in thickness from both sides by grinding using carbide bur (Germany) with continuous water-cooling [16], then the surface were smoothed using silicone carbide grit paper 240 fallowed by grade 600 until a very thin section (0.4- 0.5mm) was obtained, then polished using pumice (USA) with rag wheel (China)to be examined clearly under optical microscope [17], after that (4) equal fields of ($5mm^2$) from each specimen were made (3) of them at the periphery of the specimen and the last one at the center, then the specimens were immersed in a solution of black ink (china) for 30 minutes, washed for 10 seconds, and dried with absorbent paper [18, 19].

The fields were observed under light microscope (Italy) in a magnification of (X10); the mean of pores for each specimen was calculated by dividing the total number of pores in all of the three periphery fields by the number of those fields and comparison them with that pores located at the center [9, 20, 21]. While polishing was accomplished by using bristle brush (china) and pumice (Italy) with

lathe polishing machine (Italy). A glossy surface was obtained with wool brush (Italy) and polishing soap (USA) on dental lathe using law speed of (1500 rpm) which not lead to distortion of the specimens.

Statistical analysis

The suitable statistical methods were used in order to analyze and assess the results, they include the Descriptive statistics (mean, SD, SEM, minimum & maximum) and Inferential statistics (Analysis of variation ANOVA (f-test) and Least significant difference LSD (f-test)), tests were performed at a confidence level of 95% [22].

Results

Porosity test results are shown in table 1, 2 and figure (2):

There were a significant difference in porosity value (P<0.01) when compared between the experimental groups of the present study. There was a decrease at the level of porosity within the periphery of cold cure acrylic resin specimens that cured in Ivomat for (15) minutes (12. 80± 1.568) than that appear at the center of the same specimens (17.50± 2.718). While the porosity within the center of cold cure acrylic resin specimens that cured in Ivomat for (15) minutes showed less level in value than that appear at the center of the specimens which chemically cured under hydraulic press for (45) minutes (25.30± 1.889), and those in turn appeared to manifest high level value in porosity than those present at the periphery of the same specimens (14.27± 1.847).

Cold cure acrylic resin specimens that cured in Ivomat for (20) minutes showed lowest value in porosity level at the periphery (5.86± 1.322) than those clarified at the periphery of (15) minutes curing time (12.80± 1.568), and than that introduced at the periphery of chemically cured cold cure acrylic under hydraulic press for (45) minutes (14.27±1.847), and also it was showed decrease in porosity value than that manifested in the center of acrylic specimens that cured at both (15 & 20)minutes [(17.50± 2.718), (10.60± 2.171)] respectively. Finally the porosity at the center of the specimens which chemically cured under hydraulic press for (45) minutes (25.30± 1.889) manifested highly level in porosity than that at the periphery of cold cure acrylic which cured for (20) minutes in Ivomat (5.86± 1.322).

Table (1): Mean distribution of porosity (%) test among studied groups.

Studied groups		N	Mean	SD	S. Error	Mini.	Maxi.	ANOVA	
								P-value	Sig.
Center (One reading)	G1	10	25.30	1.889	0.597	22	28	0.00	Highly Sig.(P<0.01)
	G2	10	17.50	2.718	0.860	13	21		
	G3	10	10.60	2.171	0.686	8	15		
Average (three peripheral readings)	G1	10	14.27	1.847	0.584	12.3	18		
	G2	10	12.80	1.568	0.496	9.7	15.3		
	G3	10	5.86	1.322	0.418	3.7	8.3		
Total		60							

Average= (average of three peripheral readings in each sample for 10 specimens)

Table (2): Multi comparison for porosity (%) test among studied groups.

Studied groups		Comparison of Significant (LSD)	
		P-value	Sig.
G1-Center	G2-Center	0.00	Highly Sig.(P<0.01)
	G3-Center	0.00	Highly Sig.(P<0.01)
	G1--Average	0.00	Highly Sig.(P<0.01)
G2-Center	G3-Center	0.00	Highly Sig.(P<0.01)
	G2--Average	0.00	Highly Sig.(P<0.01)
G3-Center	G3--Average	0.00	Highly Sig.(P<0.01)
G1--Average	G2--Average	0.001	Highly Sig.(P<0.01)
	G3--Average	0.00	Highly Sig.(P<0.01)
G2--Average	G3--Average	0.00	Highly Sig.(P<0.01)

Average= (average of three peripheral readings in each sample for 10 specimens)

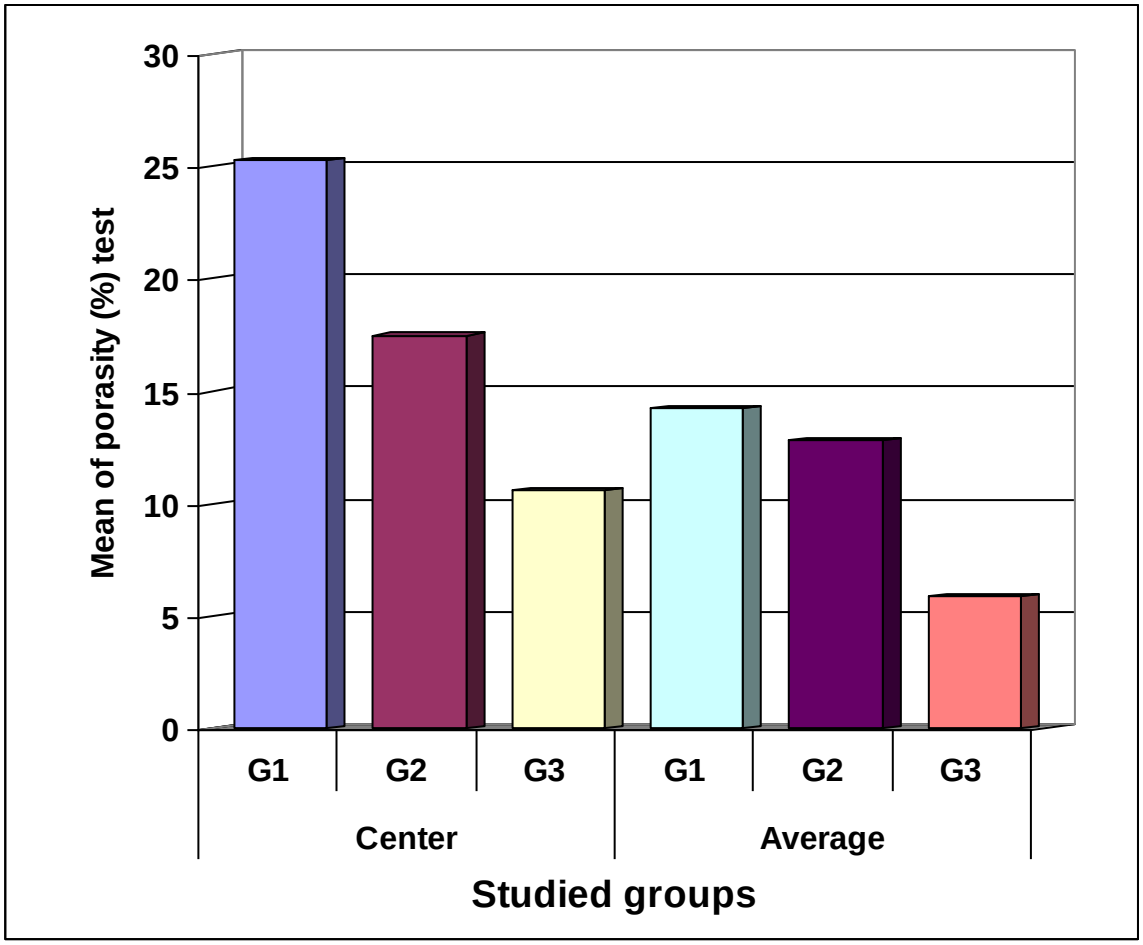

Figure (2): Mean distribution of porosity (%) test among studied groups.

Discussion

Generally all the specimens revealed more increase in porosity at the center than that at the periphery, this could be due to the direction of the polymerization in acrylic denture base material that processed via conventional techniques which begin from the surface toward the deeper part of resins, opposite that of the denture bases polymerized using microwave energy [11, 23].

Cold cure acrylic resin that cured chemically on air pressure of (4 bar) under hydraulic press for (45) minutes appear to have more percentage in porosity at the center and the periphery of specimens than that of cold cure acrylic which cured in Ivomat for (15 minutes) under air pressure of (4 bar) and in water temperature of (50 °C) , these results may be due to the presence of water which with pressure in Ivomat curing device minimize the evaporation of monomer, and this result may agree with [1, 11], this may be due to the higher degree of residual monomer in chemically curing process and also the degree of polymerization of cold cure acrylic resin chemically is not as complete as that achieved by using heat cured system.

When Cold cure acrylic resin cured in Ivomat in water temperature of (50 °C) and under pressure of (4 bar) for (20 minutes) clarifying less porosity percentage at the center and periphery of specimens than that present in cold cure acrylic which cured in Ivomat for (15 minutes), this may revealed due to the increasing in the time of curing cycle inside the curing device with the presence of water and pressure, and less residual monomer is one of the advantages of Ivomate polymerization [24], while it was showed highly decrease in porosity than that cured chemically under pressure of (4 bar) of hydraulic press for (45) minutes. This perhaps agree with [12, 25], which stated respectively that the porosity can be prevented by controlling both the rate of heating, and pressure maintained on the specimen during polymerization, and with [26] which found that the choice of suitable polymerization time is important to reduce porosity to minimum level. While these results disagree with [2], which concluded that the porosity may resulting from insufficient pressure which distributed uniformly through out the material.

Conclusion

Cold cure acrylic resin that cured chemically on air under pressure of (4 bar) of hydraulic press for (45) minutes have more porosity percentage at the center of specimens than that appeared at the center and the periphery of cold cure acrylic which cured in Ivomat for (15 & 20 minutes) under pressure of (4 bar) and in water temperature of (50 °C). While the cold cure acrylic resin which cured in Ivomat for (20 minutes) revealed less porosity percentage at the periphery than that showed at the center and the periphery of cold cure acrylic which cured in Ivomat for (15 minutes) and that cured chemically. Generally the cold cure acrylic resin which cured in Ivomat for (20 minutes) manifested lesser porosity level at the periphery than the periphery of that cured in Ivomat for (15 minutes) at the same circumstances and than that polymerizes on air, and also have less porosity percentage at the center than that of the other experimental groups.

References

1. Graig R. G.; O'Brien W. J.; and Powers J. M. (1996): Dental materials, properties and manipulation. 7th Ed. St. Louis. The C.V. Mosby Com. Pag: 242-264.

2. Graig R. G.; and Powers J. M. (2002): Restorative dental materials. 11th Ed. St. Louis. The C.V. Mosby Com.

3. Winkler S.(1984): Dent Clin of North Am J. 28(2): 287.

4. Arena C. A.; Evans D. B. and Hilton T. J. (1993): A Comparison of the bond strengths among chair side hard reline materials. J Prosthet Dent. 70 (2):126-131.

5. Kawara M.; Komiyama D.; Kimoto S.; Kobayashi N.; Kobayashi K.; and Nemoto K. (1998): Distortion behavior of heat activated acrylic denture base resin in conventional and long, low-temperature processing method. J Dent Res. 77(6): 1446-1453.
6. Cunningham J. L. (2000): Bond strength of denture base to acrylic resin. J Rehabil. 27; 312-316.
7. Takamata T.; Setcos J. C.; Phillips R. W.; and Boon M. E. (1989): adaptation of acrylic resin denture as influenced by the activation mode of polymerization. J Am Den Assoc. 19: 271-276.
8. Sadamori S.; and Hamada T. (1994): Influence of thickness and location on residual monomer content of denture base cured by three processing methods. JProsthet Dent. 72: 19-22.
9. Al-Khafaji M. T. (1998): Evaluation of some physical and mechanical properties of refabricated self-cured acrylic from used self-cured materials M. Sc. Thesis, University of Baghdad, College of Dentistry.
10. Woelfel B. J. (1977): Processing complete denture. Dent Clin North Am. 21(2): 329-339.
11. Anusavice K. J. (1996): Phillips science of dental material. 10th Ed. Philadelphia: W. B. Sounders Com. Chap: 10 and 11; Pag: 211-235, 237-271.
12. Powers J. M. and Wataha J. C. (2008): Dental materials properties and manipulation. 1st Ed. Mosby, pag; 289- 290.
13. DavenPort J. C. (1972): The denture surface. Brit. Dent. K. 133: 101-105.
14. ADA. (1999): American Dental Standers Institute / American Dental Association Specification No.12 for denture base polymer Chicage; council on dental materials and devices.
15. Abdul- Karim J. F. (2005): Evaluation of some mechanical properties of acrylic denture base materials relined with different denture reline materials. M. Sc. Thesis, College of Dentistry, University of Baghdad. Pag: 48, 73-76.
16. Truong V. T.; and Thomasz F. G. (1988): Comparison of denture acrylic resins cured by boiling water and microwave energy. Aust Dent J; 33(31):201-204.
17. Hafith M. M. (1995): A study on the effect of the chemical disinfectants on acrylic resin cured by two different techniques. MSc. Thesis, University of Baghdad. College of Dentistry.
18. Reitz P. V.; Sanders J. L.; Levin B. (1985): The curing of denture acrylic resins by microwave energy. Physical properties. Quintessence Int; 16:547-51.
19. Rodrigues Garcia R. C. M.; Del Bel Cury A. A.: Accuracy and porosity of denture bases submitted to two polymerization cycles. Indian J- Dent- Res 1996; 7: 122- 6.
20. Graig R. G. (1985): Restorative dental materials. 7th Ed. St. Louis: Mosby.
21. Al- Doori D. J. I. (1987): Polymerization of polymethyl methacrylate denture base materials by microwave energy M. Sc. thesis, University of Wales College of Medicine.
22. Sorlie D. E. (1995): edical biostatistics & epidemiology: Examination & board review. 1st Ed. Norwalk, Connecticut, Appleton & Lange: 47-88.
23. Nishii M. (1968): Studies on the curing of denture base resins with microwave irradiation with particular reference to heat curing resin. J. Osaka Dent. Univ. Japan; 2; 23-40.
24. Jorge J. H.; Glampalo E. T.; Machado A. L.; and Vergani C. E. (2003): Cytotoxicity of denture base acrylic resins: A literature review. J Prosthet Dent.; 90 (2): 190-193.
25. Harcourt J. k.; Lautenschlager E. P.; and Molnar E. J. (1969): Elastomeric mold liner in the production of porosity, Free polymethylate. J Dent Rest. 48: 61-66.
26. Lai C. P.; Tsai M. H.; Chen M.; Chan H. S.; and Tay H. H. (2004): Morphology and properties of denture acrylic resins cured by microwave energy and conventional water bath. Dent. Matr. 20(2); 133-141.