The Effect of Different Exposure Times on Some Properties of Three Types Visible Light Cured Acrylic Resins

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Background and Objectives: Visible light cured (VLC) acrylic resin is one of the developed polymeric acrylic resins found to be suitable for many dental applications: Removable, fixed, maxillofacial prostheses. The objective of this study was to evaluate the effect of different exposure times on some mechanical properties of VLC acrylic resins and compare with cold cured acrylic resins.

Materials and methods: Three types of VLC of baseplate resin materials tested; VLC (Plaque, Promedica, and Dura Base LC) materials and a cold cured acrylic resin material (Paladent RR) considered as control group. The specimens of VLC subdivided to three groups each group cured by 3 different exposure times (4 minutes, 8 minutes and 12 minutes. Testing of dimensional changes, indentation hardness and dimensional stability (adaptation) performed for all specimens.

Results: Different curing times showed a considerable influence on dimensional changes and dimensional stability of the VLC acrylic resin. The VLC baseplate material (Plaque) exhibited lowest values of dimensional expansion and volumetric dimensional changes; and highest values of indentation hardness among other VLC materials (Promedica and Dura Base LC). Regarding the control group, the cold cure resin (Paladent RR); exhibit highest values of dimensional expansion, indentation hardness and moderate values of dimensional stability.

Conclusions: The results of the present study showed that, VLC materials had properties which enable the dentist to use them for various purposes in prosthodontics purposes.

Key words: VLC, Cold-cured denture base materials, Dimensional changes, Indentation hardness, and Dimensional stability.

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Introduction

Visible light cured(VLC) acrylic denture resin systems were introduced in 1983 beside the conventional polymethyl methacrylate (PMMA) denture base resins and these materials were marketed with the purported advantages of more efficient handling, fewer patient appointments, elimination of the potential toxicity of methyl methacrylate (MMA).[1] VLC denture base consists of a urethane dimethacrylate matrix with an acrylic copolymer, microfine silica fillers, and a photoinitiator system. The VLC denture base is polymerized in a light chamber with blue light of (400 – 500) nm.[2] VLC acrylic resin can be used for a wide range of dental applications, such as repair materials, special tray, record base, patient with hyper sensitive to PMMA, and obturators materials. This materials exhibit superior handling characteristics compared to chemically–cured material.[3-6] The energy which is needed for polymerization of the VLC material is electromagnetic energy, and the initiator needed for polymerizati-

on is called photoinitiator[7]. Few researchers supported VLC resin as a replacement for heat-cured PMMA as a denture base material. since the clinical trials revealed that VLC denture base resins are currently not sufficiently durable to make them a viable alternative to conventional acrylic resin and further modifications are required to improve its physical properties before its wide spread introduction for use as a routine material in dentistry.[8]

Materials and methods

Methods. One hundred eighty-nine (189) specimens of VLC acrylic (Plaque, Promedica, and Dura Base LC) prepared; they divided to three equal groups cured by 3 different exposure times: The first group cured 4 minutes, the second cured 8 minutes, while the third group was cured 12 minutes. These groups compared to 21 specimens of cold-cured acrylic resin which considered as the control group. The cured specimens in each group subdivided to 3 equalgroups; each group was exposed to one of the following testes: Dimensional changes, Shore indentation hardness, Dimensional stability (adaptation). The curing of the VLC specimens performed in a visible light curing chamber, for each different exposure times (4, 8 and 12 minutes); the specimen was cured half the time then inverted and exposed to light for the remaining time to insure complete polymerization.

For dimensional changes test, 21 rectangular specimens from each brand of VLC materials measured (20*12*3) mm, length, width and thickness respectively cut down from uncured blanks. Four circular holes (A, B, C, D) one in each corner, 2 mm away from borders prepared by pressing a metal stamp has 4 projections on the mentioned areas. The stamp (which was prepared by casting metal into a prepared mold) fixed on a locally made equipment has a movable handle when lowering it press the uncured specimens, the 4 holes produced on the surface of the specimens by the effect of the 4 projections. The distance between the depressions were measured before and after curing, using a travelling microscope. The variation in dimension was measured according to the equation

$$||\overrightarrow{V}|| = \sqrt{(AB)2 + (BC)2 + (CD)2 + (CA)2}$$

Where AB=distance between A and B and so on, V=vector of distance.

For indentation hardness test 70 specimens prepared (21 specimens from each brand of VLC material ((Plaque, Promedica and Dura Base LC)) and 7 specimens from cold-cured acrylic resin. They prepared with the dimensions of (35mm * 25mm * 3mm) length, width and thickness respectively.[9] Shore indentation hardness tester type D used for measuring the indentation hardness of each specimen. Sufficient force was applied to obtain firm contact between the indenter of the tester and specimens, held for 1-2 seconds, the maximum reading obtained automatically. Three indentations made for each specimen and the average of the measurements calculated.

For dimensional stability test, a blank of VLC acrylic (21 blanks from each brand) adapted to metal standard complete dentulous cast. For standardization, a locally made equipment was used for adaptation. The metal cast fixed on a lower stand of the equipment, the upper arm of the equipment carried a metal part produced from copying of the metal cast by silicone rubber base, a mold prepared and molten metal casted into the mold; the upper metal part and lower standard metal mold represented male and female. When the uncured blank placed over the standard metal cast the upper part which fixed to a movable arm used to adapt the blank over the cast. Separating medium applied to both parts of the equipment. The material was cured by the three different mentioned exposure times. For the cold curing acrylic resin, the same

equipment used for adaptation of the acrylic resin at dough stage to the standard cast.

After curing the distance between the inner surface of the VLC and cold curing acrylic resin adapted and the cast at 3 selected points (A, B, C) on the posterior border of the cast, was measured by using Traveling Microscope. Points A and C where over the right and left crest of the ridge respectively, while point B was located at the midway between the points A and C.

Statistical analysis. The statistical analysis was carried out using software Statistical Package for Social Sciences (SPSS). One-way analysis of variance (ANOVA)was used for comparison of comparative significance among different groups. Least Significant Difference (LSD) was used to compare between each two specific means within the list of means analyzed by ANOVA. P value of ≤0.05 was considered statistically significant.

Results

Dimensional changes. The VLC Plaque material statistical analysis showed in Table (1) revealed that an increase in liner dimensional changes associated with increasing different exposure times from 4 to 12 minutes, in case of Dura Base LC there was decrease in liner dimensional changes after curing with 3 different exposure times, while in case of Promedica material there was no significant differences. Cold cured denture base materials exhibit liner dimensional changes more than all brands of (VLC)

Indentation hardness. Statistical analysis showed in Table (2) revealed that there was no significant effect for most of different exposure times on the indentation hardness of the 3 brands of (VLC), while the difference between the 3 VLC acrylic resins and cold curing acrylic resin was highly significant. The mean values of the indentation hardness of the 3 types of VLC acrylic resin was less the indentation hardness of cold curing acrylic resin.

Dimensional stability. Statistical analysis showed in Table (3) revealed that Plaque and Promedica materials exhibited significant changes in volumetric dimensional changes, after they were exposed to 3 different exposure times, While Dura Base LC material exhibited no significant volumetric dimensional changes after it was exposed to3 different exposure times, the less dimensional changes exhibited by Plaque material (best dimensional stability), followed by cold cured, Promedica and finally Dura Base. The less dimensional changes exhibited by Plaque material (best dimensional stability), followed by cold cured, Promedica and finally Dura Base LC.

Discusion

Dimensional changes. An increase in liner dimensional changes exhibited by Plaque VLC material after curing with 3 different exposure times, Dura Base LC there showed decrease in liner dimensional changes after curing with 3 different exposure times, while in case of Promedica material there was no significant differences, this may be explained by that the inorganic filler consists of small amounts of microfine amorphous silica filler particles, the filler content is about 15%, the presence of fillers are thought to control rheology, restrict dimensional polymerization shrinkage, adding bulk, increase the wear resistance and mechanical properties of the material also enhanced, like indentation hardness and compressive strength[10]. The conversion of monomer into polymer in 3 brands of VLC denture resins was investigated. The relationship of the inorganic filler content to this conversion was also studied. It was determined that these materials vary in monomer conversion and weight percentage of filler, and this variation is brand dependent. The monomer conversion ranged from 77% to 97% significant differences in these values were found when duration of light exposure was increase1.The cold cured acrylic resin

exhibit liner dimensional changes more than all brands of VLC, this may be due to VLC materials polymerization was electromagnetic while in case of cold-cured the polymerization was of

Table 1: Least significant differences test (LSD) represented the mean difference, P-values of dimensional changes among tested groups at the level of 0.05 significant.

Dependent Variable	(I) Time	(J) Time	Mean Difference (I-J)	P-Value.
Plaque	4 Minutes	8 Minutes	-0.034286	0.707
		12 Minutes	-.290000(*)	0.004
		Control	-.634286(*)	0.000
	8 Minutes	4 Minutes	0.034286	0.707
		12 Minutes	-0.255714(*)	0.009
		Control	-0.600000(*)	0.000
	12 Minutes	4 Minutes	0.290000(*)	0.004
		8 Minutes	0.255714(*)	0.009
		Control	-0.344286(*)	0.001
	Control	4 Minutes	0.634286(*)	0.000
		8 Minutes	0.600000(*)	0.000
		12 Minutes	0.344286(*)	0.001
Promedica	4 Minutes	8 Minutes	0.027143	0.765
		12 Minutes	0.008571	0.925
		Control	-0.321429(*)	0.002
	8 Minutes	4 Minutes	-0.027143	0.765
		12 Minutes	-0.018571	0.838
		Control	-.348571(*)	0.001
	12 Minutes	4 Minutes	-0.008571	0.925
		8 Minutes	0.018571	0.838
		Control	-0.330000(*)	0.001
	Control	4 Minutes	0.321429(*)	0.002
		8 Minutes	0.348571(*)	0.001
		12 Minutes	0.330000(*)	0.001
Dura Base LC	4 Minutes	8 Minutes	0.191429(*)	0.031
		12 Minutes	0.228571(*)	0.012
		Control	-0.335714(*)	0.001
	8 Minutes	4 Minutes	-0.191429(*)	0.031
		12 Minutes	0.037143	0.661
		Control	-0.527143(*)	0.000
	12 Minutes	4 Minutes	-0.228571(*)	0.012
		8 Minutes	-0.037143	0.661
		Control	-0.564286(*)	0.000

	Control	4 Minutes	0.335714(*)	0.001
		8 Minutes	0.527143(*)	0.000
		12 Minutes	0.564286(*)	0.000

Table 2: Least significant differences test (LSD) represented the mean difference, P-values of indentation hardness among tested groups at the level of 0.05 significant.

Dependent Variable	(I) Time	(J) Time	Mean Difference (I-J)	P-Value.
Plaque	**4 Minutes**	8 Minutes	0.19857	0.935
		12 Minutes	5.43143(*)	0.034
		Control	-9.87857(*)	0.000
	8 Minutes	4 Minutes	-0.19857	0.935
		12 Minutes	5.23286(*)	0.040
		Control	-10.07714(*)	0.000
	12 Minutes	4 Minutes	-5.43143(*)	0.034
		8 Minutes	-5.23286(*)	0.040
		Control	-15.31000(*)	0.000
	Control	4 Minutes	9.87857(*)	0.000
		8 Minutes	10.07714(*)	0.000
		12 Minutes	15.31000(*)	0.000
Promedica	**4 Minutes**	8 Minutes	-1.07000	0.547
		12 Minutes	1.87571	0.295
		Control	-16.23571(*)	0.000
	8 Minutes	4 Minutes	1.07000	0.547
		12 Minutes	2.94571	0.106
		Control	-15.16571(*)	0.000
	12 Minutes	4 Minutes	-1.87571	0.295
		8 Minutes	-2.94571	0.106
		Control	-18.11143(*)	0.000
	Control	4 Minutes	16.23571(*)	0.000
		8 Minutes	15.16571(*)	0.000
		12 Minutes	18.11143(*)	0.000
Dura Base LC	**4 Minutes**	8 Minutes	2.38000	0.165
		12 Minutes	1.78286	0.294
		Control	-19.99143(*)	0.000
	8 Minutes	4 Minutes	-2.38000	0.165
		12 Minutes	-0.59714	0.722
		Control	-22.37143(*)	0.000
	12 Minutes	4 Minutes	-1.78286	0.294
		8 Minutes	0.59714	0.722

		Control	-21.77429(*)	0.000
	Control	4 Minutes	19.99143(*)	0.000
		8 Minutes	22.37143(*)	0.000
		12 Minutes	21.77429(*)	0.000

Table 3: Least significant differences test (LSD) represented the mean difference, P-values of dimensional changes (sum points A, B and C) among tested groups of dimensional stability at the level of 0.05 significant.

Dependent Variable	(I) Time	(J) Time	Mean Difference (I-J)	P-Value.
Plaque	**4 Minutes**	8 Minutes	-0.81714(*)	0.000
		12 Minutes	-0.65857(*)	0.000
		Control	-0.77857(*)	0.000
	8 Minutes	4 Minutes	0.81714(*)	0.000
		12 Minutes	0.15857	0.321
		Control	0.03857	0.807
	12 Minutes	4 Minutes	0.65857(*)	0.000
		8 Minutes	-0.15857	0.321
		Control	-0.12000	0.451
	Control	4 Minutes	0.77857(*)	0.000
		8 Minutes	-0.03857	0.807
		12 Minutes	o.12000	0.451
Promedica	**4 Minutes**	8 Minutes	-0.41857(*)	0.042
		12 Minutes	-0.13857	0.483
		Control	-0.05000	0.799
	8 Minutes	4 Minutes	0.41857(*)	0.042
		12 Minutes	0.28000	0.163
		Control	0.36857	0.070
	12 Minutes	4 Minutes	0.13857	0.483
		8 Minutes	-0.28000	0.163
		Control	0.08857	0.653
	Control	4 Minutes	0.05000	0.799
		8 Minutes	-0.36857	0.070
		12 Minutes	-0.08857	0.653
Dura Base LC	**4 Minutes**	8 Minutes	-0.19000	0.347
		12 Minutes	-0.13714	0.495
		Control	0.39143	0.060
	8 Minutes	4 Minutes	0.19000	0.347
		12 Minutes	0.05286	0.792
		Control	0.58143(*)	0.007
	12 Minutes	4 Minutes	0.13714	0.495

		8 Minutes	-0.05286	0.792
		Control	0.52857(*)	0.013
	Control	4 Minutes	-0.39143	0.060
		8 Minutes	-0.58143(*)	0.007
		12 Minutes	-0.52857(*)	0.013

chemical reaction, so heat generation occurred during chemical reaction was more than that occurred during electromagnetic polymerization. The Inorganic Filler Consists of small amounts of microfine amorphous silica filler particles, the filler content is about 15%, the presence of fillers is thought to control rheology, restrict dimensional polymerization shrinkage. These results were in agreement with the results of 11, 12 and 13.

Indentation hardness. Non- significant effect for different exposure times on the indentation hardness of the 3 brands of (VLC), be due to that the:VLC acrylic resin had trace or no residual monomer, since its presence reduce resin indentation hardness.VLC materials had inorganic filler in its composition so there was a reduction in proportion of the resin matrix.[1,2]These results were in agreement with a study performed previously.[14] The cold cured acrylic was harder than all brand of VLC and these results were in disagreement withprevious studies,[15-17] this may be due to the number of the specimens (7 specimens) which was small size of specimens in comparison to the large size of specimens of VLC, which was 63 specimens.

Dimensional stability. Plaque and Promedica VLC materials exhibited significant changes in volumetric dimensional changes, after they were exposed to different exposure times, this may be explained by that: The high dimensional changes of VLC materials are affected by the polymerization reaction of the matrix phase which is an immediate and rapid reaction in which the material transformed from a viscous plastic phase through which it can flow and relieve stresses within the developing polymer structure, into a rigid elastic phase, as flow of the material ceases and can no longer compensate for shrinkage stresses that occur when contraction is obscured and the material is rigid enough to resist sufficient plastic flow to compensate for the original volume 18. Dura Base LC material exhibited no significant volumetric dimensional changes after it was exposed to 3 different exposure times, this may be due to: The conversion of monomer into polymer in 3 brands of VLC resins was investigated. The relationship of the inorganic filler content to this conversion was also studied. It was determined that these materials vary in monomer conversion and weight percentage of filler, and this variation is brand dependent. The monomer conversion ranged from 77% to 97% significant differences in these values were found when duration of light exposure was increase.[1] The less dimensional changes exhibited by Plaque material (best dimensional stability), followed by cold cured, Promedica and finally Dura Base LC , may be due to that: control group (cold cured) materials polymerized at a low rate, and the polymerization process is not as complete, so less stress would be produced; less shrinkage displayed which imparts greater dimensional stability[19]. The results of this study were in agreement with previous studies.[20-22] While disagreed with the results of one other study[23]; this may be explained by that: dimensional changes in relined denture bases were influenced by the relining materials and procedures.

Conclusions

The different curing times have a considerable influence on dimensional changes, dimensional stability (adaptation to the underlying cast) of the VLC denture base materials. The VLC materials had properties which enable the dentist to use them for

various purposes in prosthodontic in laboratory purposes especially for (Plaque) VLC materials.

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