The Effect of Different Light Cure Systems on Microhardness of Bulk Fill Composite Materials

Linz A. Shalan, B.D.S., M.Sc. [(1)]
Samer Awn Thiab, B.D.S., M.Sc. [(2)]

ABSTRACT

Background: The aim of this study was to evaluate the effect of three types of light curing devices QTH, LED and Flashmax on the surface microhardness of three types of bulkfill composite resins; Filtek Bulkfill posterior composite (3M), Tetric Evo Ceram (Ivoclar Vivadent) and Sonicfill composite (Kerr)

Materials and methods: Total number of 90 samples was prepared, 30 samples for each type of bulkfill composite, were divided into three main groups, group A: Filtek posterior bulkfil (3M), group B: Tetric Evo Ceram (Ivoclar Vivadent) and group C: contain Sonicfill composite (kerr). Which then divided into three subgroups (n= 10) (1) Samples cured by QTH system (2) Samples cured by LED system and (3) samples cured by Flashmax system then all samples were subjected for microhardness test (by Vickers hardness tester). The data were recorded and statistically analyzed, by the ANOVA and the Tukey test.

Results: the data was subjected to statistical analysis using one way ANOVA and Tukey test, the result revealed that there was a high significant difference among the tested units with LED had high VHN values followed by QTH while Flashmax had lowest VHN values, also there was high significant difference among the tested materials in which Sonicfill composite had higher VHN value followed by Tetric EvoCeram while Filtek bulkfill posterior composite had the lowest VHN.

Conclusions: microhardness of the composite resin materials depend upon energy of the curing device, time of exposure, composition of the composite material.

Key word: microhardness, bulkfill composite, Flashmax, Sonicfill. . **(J Bagh Coll Dentistry 2017; 29(2):13-20)**

INTRODUCTION

Bulk-fill composites are popular restorative materials that have been in the market for several years, unlike traditional composites, which typically are placed in maximum increments of 2 mm, bulk-fill composites are designed to be placed in 4 mm, or sometimes greater increments. Restoring a tooth in one step certainly appears to save time, there are some concerns. For example, manufacturers claim that bulk-fill materials have greater depth of cure and lower polymerization-induced shrinkage stress. One proposed rationale for limiting composite increments to 2 mm is to allow the curing light to penetrate to the resin farthest away from the light source [(1)].

A second reason for using 2-mm increments is to minimize the shrinkage and shrinkage-induced stress associated with composite polymerization. Contraction stresses that exceed the adhesive strength of the composite may result in gaps between composite and cavity walls. It is widely believed that these marginal gaps may lead to microleakage, sensitivity and secondary caries, although there is little clinical evidence to support that secondary caries are caused by this gap formation [(2)].

Polymerization of the core of the restoration is directly related to the material's chemical composition, the organic (type of matrix) or inorganic portion (type and morphology of filler contents).

Moreover, it is influenced by the thickness of the increment inserted into the cavity, intensity and irradiation time, light spectrum, and distance of the tip of the light curing unit to the material to be activated [(3)]. Factors affecting resin-based composites' depth of cure have been identified mainly as curing source intensity and light exposure duration, filler size and content, interactions at the filler-matrix interface, shade and translucency [(2)].

However, the polymerization reaction cannot be considered finished after exposure to light due to the presence of what is called "dark polymerization" [(4)]. It can be explained by the presence of a temporary excess of free volume of monomers with enough mobility that allows molecules to still interact at lower rates. It has been reported that the values of resin conversion for most of the commercial dental composites vary from 40-75% [(4)].

SonicFill™ composite (Kerr Corp., USA) is a nanohybrid, low-shrink, resin-based, radiopaque, sonic-activated, bulkfill composite material designed for direct placement for all cavity classes in posterior teeth without additional capping layer. It allows a depth of cure of 5mm, incorporates a highly-filled proprietary resin with special rheological modifiers that react to sonic energy. As sonic energy is applied through the hand piece,

(1) Assist. Professor,. Department of Conservative Dentistry, College of Dentistry, University of Baghdad.
(2) Lecturer. Department of Conservative Dentistry, College of Dentistry, University of Baghdad.

the modifier causes the viscosity to drop (up to 87%), increasing the flow ability of the composite and enabling quick replacement and precise adaptation to the cavity walls. When the sonic energy is stopped, the composite returns to a more viscous, non-slumping state for curving and contouring [5].

The light-curing unit plays a more influential role in the basic properties of resin-based composites. Quartz-tungsten-halogen (QTH) units have been widely used for polymerizing resin-based dental materials for decades. QTH units exhibit several shortcomings, so, as an alternative, light-emitting diode (LED) light curing units were introduced for polymerizing resin-based composites. However, conflicting results have often been observed in the literature as related to the effects of both light curing units [5].

Recently, resin-based composite curing lights have been developed that have higher intensities and shorter curing cycles which help speed the resin-based curing [4]. One of these new high intensity light curing units is the Flash Max P3(CMS Co., Denmark) whose light intensity ranges from 4000-5000 mW/cm2 and supposed to give 6 mm curing depth in only three seconds as claimed by the manufacturer [6].

The relative importance of a microhardness test lies in the fact that it throws a light on the mechanical properties of a material. The higher the degree of conversion, the better the mechanical properties, hardness, biocompatibility, water sorption, color stability and wear resistance of the resin composite [7]. Microhardness is often traditionally used as indirect measurement of effectiveness of composite cure or the degree of conversion, so the aim of this study was to evaluate and compare the influence of different light curing system (conventional QTH, soft start LED and Flashmax) on micro hardness of three types of Bulkfill composite (Filtek Bulkfill posterior composite, Tetric Evo Ceram bulkfill, sonic fill composite).

MATERIALS AND METHODS

Three types of bulkfill composite were used in this study 1. Filtek Bulkfill posterior composite (3M). 2. Tetric Evo Ceram (Ivoclar Vivadent), 3. Sonic fill composite (Kerr). Their composition and shade presented in table (1) three light curing device were used 1. QTH, 2. LED, 3. Flashmax their intensity and exposure times presented in table (2), Sonicfill composite and Filtek bulkfill posterior composite comes in universal shade, while Tertic Evo Ceram comes in three shades IVA, IVB and IVW. In this study we use the lighter shade IVA.

Grouping

Group A: contain 30 samples made from Filtek Bulkfill posterior composite (3M) subdivided into 3 subgroup

Group A1: contain 10 samples of Filtek Bulkfill posterior composite cured by QTH.

Group A2: Contain 10 samples of Filtek Bulkfill posterior composite cured by LED.

Group A3: Contain 10 samples of Filtek Bulkfill posterior composite cured by Flashmax.

Group B: contain 30 samples made from Tetric Evo Ceram composite (Ivoclar Vivadent) subdivided into 3 subgroup

Group B1: contain 10 samples of Tetric Evo Ceram composite cured by QTH.

Group B2: Contain 10 samples of Tetric Evo Ceram composite cured by LED.

Group B3: contain 10 samples of Tetric Evo Ceram composite cured by Flashmax.

Group C: contain 30 samples made from Sonicfill composite (Kerr) subdivided into 3 subgroup

Group C1: contain 10 samples of Sonicfill composite cured by QTH.

Group C2: contain 10 samples of Sonicfill composite cured by LED.

Group C3: contain 10 samples of Sonicfill composite cured by Flashmax.

Sample preparation:

Two-piece aluminum mold with a diameter of 6mm and a height of 4mm [7] was used for the preparation of composite specimens for the evaluation of the depth of cure. A celluloid strip was placed on a flat glass slide on top of a white background. The aluminum mold was then placed on it and slightly over filled in one increment with one of the composite materials and a second celluloid strip was then placed on top of the mold and overlaid with another glass slide with the application of 100gm load to extrude excess material. The top slide was then removed and the composite resin light-cured with either of the following curing units: (1) quartz tungsten-halogen (QTH) light curing unit (Ivoclar), (2) LED light curing unit (USA)(3) FlashMax P3high intensity LED curing unit (CMS Co., Denmark). The tip of the light curing unit was placed in direct contact with the overlaid celluloid strip.

The light guide of QTH light curing unit has a diameter of 4mm, while the FlashMaxP3 light curing unit is supplied with two light guides: a 4mm tip and an 8mm tip light guides. The 4mm tip was used in this study for the purpose of standardization, after completing the light curing procedure, the over laid celluloid strip was removed and the aluminum mold was opened. Then stored for 24hours in a light proof container with distilled water at 37˚c to complete polymerization and inhibit any further polymerization from transient light [7].

Relative microhardness was measured by doing the surface microhardness test on both sides of the samples (top and bottom) to give indication about the depth of cure by calculating the ratio of bottom/top hardness. A minimum value of 0.80 have to be reached in order to consider the bottom microhardness of the samples was determined using Vickers Microhardness tester (MicroMet 6040 Wilson Microhardness; BUEHLER, U.S.A.).

Table 1: Composition of the tested composite materials

Product	The resin matrix:	The filler:	Filler size	Filler loading	Manufacture	Shade
Filtek Bulk Fill, Posterior restorative	AUDMA, UDMA, and 1, 12-dodecane-DMA.	Silica filler, a zirconia fill and ytterbium trifluoride filler	4-20nm	76.5%-Wt	3M ESPE, St. Paul, USA	A2
Tetric EvoCeram Bulk Fill	Bis-GMA UDMA Bis-EMA	Ytterbium fluoride, barium aluminium silicate glass	550 nm (mean)	80% wt	Ivoclar vivadent	A
Sonic fill	Bis-EMA TEGDMA	Silicon dioxide Glass, oxide, chemicals Zirconium compound Ytterbium triflouride	0.4µm-30nm	83% wt	Kerr	A2

Table 2: curing systems used in this study

Device	Intensity	Exposure time	Wave length	Manufacturer
QTH	400	40 S	400-500	Ivoclar, Austeria
LED	460	40 S	440-480	USA
Flashmax	4000	3 s	4000-5000	Denmark

RESULTS

Statistical analysis among groups for the effect of light curing system on tested materials:

Descriptive analysis for both top and bottom surfaces:

Means, standard deviation for microhardness values VHN for the three tested curing systems on both top and bottom surfaces the result showed that LED had the highest means followed by QTH and lowest mean value for Flashmax as shown in table (3).

Interfacial analysis

ANOVA test was made among tested groups for both top and bottom surfaces which revealed a high significant differences ($p<0.001$) in microhardness values HV among groups as shown in table (3).

Table 3: Descriptive & ANOVA for the effect of tested light curing systems on top and bottom surfaces of the tested materials

groups	subgroups	Descriptive & ANOVA for top surface					Descriptive & ANOVA for bottom surface				
		Mean	Std. Deviation	F	P-value	sig	Mean	Std. Deviation	F	p-value	sig
QTH	A1	53.44	7.14	16.993	0.001	HS	39.11	4.94	28.667	.000	HS
	B1	56.94	4.41				49.08	3.56			
	C1	67.04	4.20				32.91	5.71			
LED	A2	58.93	5.01	24.557	0.001	HS	46.79	5.34	16.664	.000	HS
	B2	59.49	4.04				54.81	4.62			
	C2	70.36	3.04				43.34	3.53			
Flashmax	A3	49.68	3.04	54.921	0.001	HS	57.06	1.40	25.736	.000	HS
	B3	52.99	2.71				65.36	4.97			
	C3	64.50	4.06				51.62	5.40			

The data revealed from ANOVA test analyzed by Tueky's test for all tested material for both top and bottom surfaces which showed that for (top surface) the materials which cured by QTH there was a non-significant difference ($p<0.05$) between group A1 and B1, High-significant differences between group A1 and C1 ($p< 0.001$), Highly significant differences between group B1 and C1 ($p< 0.001$) in microhardness value VHN. For LED there was non-significant difference ($p< 0.05$) between group A2 and B2, a High-significant difference ($p< 0.001$) between A2 and C2, high significant differences between B2 and C2.

For Flashmax there was non-significant difference between A3 and B3, also High-significant differences between A3 and C3, high significant differences between B3 and C3 as shown in table (4) and figure (1). For the (bottom surfaces) Tukey test revealed that for QTH there was a High significant differences between group A1 and B1, a Significant differences between group A1 and C1($p> 0.01$), a High significant differences between group B1 and C1($p< 0.001$).

For LED there were high significant differences between A2 and B2, significant differences between A2 and C2, High significant differences between groups B2 and C2.

For Flashmax there was a high significant difference between group A3 and B3, significant differences between A3 and C3, High significant differences between B3 and C3 as shown in table (4).

Table 4: Tukey test for the effect of light curing systems on top and bottom surfaces of the tested materials

			Tukey test for top surface			Tukey test for bottom surface		
Groups	**sub-groups**		**Mean diff**	**p-value**	**sig**	**Mean diff**	**p-value**	**sig**
QTH	**A1**	**B1**	-3.50	.333	NS	-9.97	.000	HS
		C1	-13.60	.000	HS	6.20	.021	S
	B1	**C1**	-10.10	.001	HS	16.17	.000	HS
LED	**A2**	**B2**	-0.56	.950	NS	-8.02	.001	HS
		C2	-11.43	.000	HS	3.45	.020	S
	B2	**C2**	-10.87	.000	HS	11.47	.000	HS
Flashmax	**A3**	**B3**	-3.31	.084	NS	-8.30	.001	HS
		C3	-14.82	.000	HS	5.44	.020	S
	B3	**C3**	-11.51	.000	HS	13.74	.000	HS

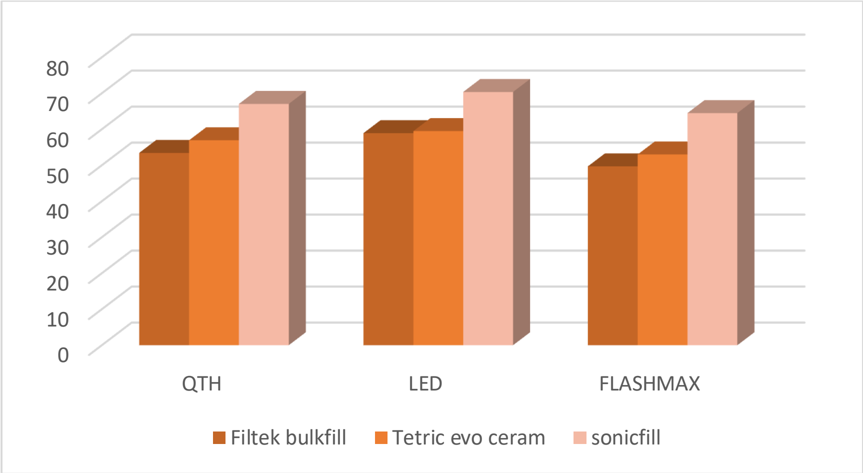

Figure 1: A chart show the effect of curing system on VHN for the top surfaces of the tested materials

Descriptive and interfacial analysis for microhardness according to the type of material:

Descriptive statistics for both top and bottom surfaces:

Means, standard deviation for microhardness values VHN for the three tested composite materials for both top and bottom surfaces are listed in table (3), the result showed that Sonicfill composite had the highest means followed by

Tetric Evo Ceram and lowest mean value for Filtek Bulkfill composite as shown in table (5).

Table 5: Descriptive and interfacial statistics for top and bottom surfaces for the tested materials group

		Descriptive & ANOVA for top surface					Descriptive & ANOVA for bottom surface				
Groups	**Subgroup**	**Mean Top surface**	**SD**	**F**	**P-value**	**sig**	**Mean bottom surface**	**SD**	**F**	**p-value**	**sig**
Filtek Bulk fill posterior	**A1**	53.44	7.13	7.612	0.002	HS	39.01	4.7	26.05	0.000	HS
	A2	58.93	5.01				48.08	3.73			
	A3	49.68	3.04				32.91	5.71			
Tetric Evo Ceram	**B1**	56.94	4.41	7.46	0.003	HS	46.69	5.05	16.99	0.000	HS
	B2	59.49	4.04				53.81	3.92			
	B3	52.99	2.7				43.34	3.53			
Sonic fill	**C1**	67.04	4.2	8.81	0.001	HS	57.03	2.31	24.14	0.000	HS
	C2	70.36	3.04				64.56	4.39			
	C3	64.5	4.05				51.62	5.4			

Inferential statistics

Statistical analysis of data by using ANOVA test for all groups of tested composite revealed that there is a high significant differences (p< 0.001) in microhardness values VHN among the groups for each composite material after curing with different light curing systems in both top and bottom surfaces as shown in table (5).

The data revealed from ANOVA test analyzed by Tueky test for all tested material for both top and bottom surfaces which showed that for (top surface) of Filtek Bulkfill posterior composite there was anon-significant difference (p< 0.05) between group A1 and A2, non-significant differences between group A1 and A3 (p< 0.05), highly significant differences between group A2 and A3 (p< 0.001) in microhardness value VHN. For Tetric-Evo Ceram there was non-significant difference (p< 0.05) between group B1 and B2, a non-significant difference between B1 and B3, High significant differences between B2 and B3.

For Sonicfill composite there was non-significant difference between C1 and C2, also non-significant differences between C1 and C3, high significant differences between C2 and C3 as shown in table (6) and fig (2).

Table 6: Tukey test for the groups of tested materials for both top and bottom surfaces.

			Tukey test for top surface			Tukey test for bottom surface		
Groups	**Sub-groups**		**Mean diff**	**p-value**	**sig**	**mean diff**	**p-value**	**sig**
Filtek bulkfill	**A1**	**A2**	-5.49	0.073	NS	-10.07	0.000	HS
		A3	3.76	0.273	NS	5.10	0.01	S
	A2	**A3**	9.25	0.002	HS	15.17	0.000	HS
Tetric Evo ceram	**B1**	**B2**	-2.55	0.305	NS	-8.12	0.001	HS
		B3	3.95	0.069	NS	2.35	0.037	S
	B2	**B3**	6.5	0.002	HS	10.47	0.000	HS
Sonic fill	**C1**	**C2**	-3.32	0.104	NS	-8.53	0.000	HS
		C3	3.24	0.114	NS	4.41	0.019	S
	C2	**C3**	6.56	0.001	HS	12.94	0.000	HS

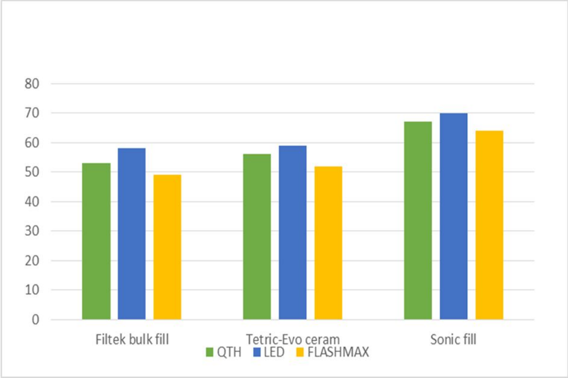

Figure 2: Chart for the microhardness value for the three tested materials top surfaces

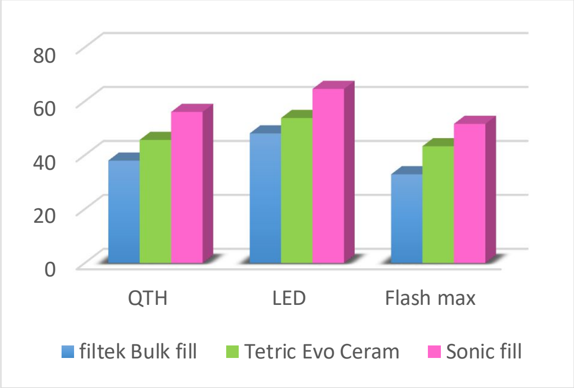

Figure 3: Chart for the microhardness value for the three tested materials bottom surfaces

Tukey test for bottom surface showed that for Filtek Bulkfill posterior composite there was a High significant differences among group A1 and A2, Significant differences among group A1 and A3, High significant differences among A2 and A3. For Tetric Evo Ceram High significant differences between group B1 and B2, significant differences between B1 and B3, High significant differences between group B2 and B3. For Sonicfill there was High significant differences between C1 and C2, Significant differences between group C1 and C3, High significant differences between group C2 and C3 as shown in table (6) and fig(3)

Another analyses were made between top to bottom for each material following this equation Bottom/top =Ratio as shown in table (7).

Form table (7) all tested material reach the Top/bottom ratio of 0.8 except for Filtek Bulk fill posterior composite cured with QTH (group A1) and cured with Flashmax (group A3).

Table 7: Bottom/ top ratio for all groups

Group	Subgroup Top/bottom ratio	Top/bottom ratio
Filtek bulkfill	A1	0.711
	A2	0.815
	A3	0.662
Tetric Evo ceram	B1	0.802
	B2	0.904
	B3	0.817
Sonic fill	C1	0.835
	C2	0.917
	C3	0.8

DISCUSSION

Effect of light cure system on microhardness:

If the resin composite does not receive sufficient total energy various problems may occur with the final restoration such as the reduction in the amount of monomer to polymer conversion an increased cytotoxicity of the restorative material, reduction in the hardness of the restorative material. Adequate polymerization of the light cured composite materials depend upon (1) light activation energy (2) wave length (3) curing time.

In this study LED show highest microhardness VHN value for all tested material followed by QTH and the lowest VHN value for Flashmax as shown in tables (3), fig (1) for both top and bottom (4 mm depth) for all tested groups. This can be explained by analyses of total amount energy density of the system which is an important parameter and it is the amount of energy of appropriate wavelength emitted during irradiation. This energy is calculated as the product of the output of the curing light unit and the time of irradiation which can be calculated from the equation:

Energy density= Intensity x Time [10]

As a result QTH have energy density 16 J/cm^2, LED has energy density 18.4 J/cm^2 and Flashmax have energy density 12 J/ cm^2. This results agree with findings [11,12].

Also the depth of cure of composite resin is mainly dependent on exposure time of the light source to the composite resin [9] therefore, the short curing time for Flashmax unit as recommended by manufacturer (table 2) led to low VHN value for the tested materials this can be explained as the duration of the exposure will allow the excited camphorquinon (typical photosensitive agent in light cured dental resin composites) molecules to diffuse and react with a mine and it is important to increase exposure duration and use appropriate light curing device to maximize the hardness of the resin materials[13]. This result agree with previous studies [9,13,14]

Effect of the material on the microhardness:

Sonicfill composite had the highest microhardness value VHN among the tested composite material in all used curing system as shown tables (5,6) and figure (2,3), From both top and bottom curing value followed by Tetric Evo Ceram composite and the lowest microhardness value VHS for Filtek Bulk fill posterior composite. This in agreement with previous studies [12,15]. which claimed that Sonicfill system had the highest score among the tested materials and can be used as an alternative to regular composite for posterior teeth [12] .This is related to several factors (1) the Nano-filling technology which led to material have better mechanical properties than other types of composite [12] (2) the optical properties of resins (optical transmission coefficient) which vary with material composition (particle type, contents and size) [16], from table (1) Sonicfill composite have higher filler loading (83%) followed by Tetric Evo Ceram (80%) and Filtek Bulkfill posterior composite (76.5%) this result in agreement with previous study [15,16] , as an increase in filler content results in higher hardness means. As regard the size of the incorporated fillers, the filler particles in the resin based composites scatter light, this scattering effect is increased as the particle size of the fillers in the composite approaches the wavelength of the activating light and will reduce the amount of light that is transmitted through the composite [16].

Material with the smallest filler particles size (0.19-3.3µm) showed the highest values of overall light transmittance for all filler contents, where as those with larger size (0.04-10) µm showed lower light transmittance for all filler contents [17] from table (1) the Sonicfill composite had the smaller size of filler particles and this result in agreement the previous studies [16]. So as regards the particle type the zirconium is harder than heavy-metal glass and the crystalline form (zirconium silica) is harder than non-crystalline (glass) and it diffuse light as it penetrate [16].

Optical properties of Sonicfill can explain the higher microhardness of Sonicfill composite as compared with Tertic Evo Ceram although both of them are nanohybrid composite this in agreement with previous studies [5]. Also Tetric Evo Ceram bulk fill composite exhibits a statistical higher microhardness value than Filtek Bulk fill posterior composite may be attributed to the presence of polymerization booster (Ivocerin) which it is highly reactive photoinitiator system allows a faster, deeper curing than other composites and it is allow application larger increments with greater depth of up 4mm in very short time and light sensitivity inhibitor which integrated into photoinitior system and act as a protective shield against ambient light like operating light [12].

Effect of depth of the material on microhardness

The microhardness of resin composites are affected by the resin composite thickness [18], in the present study the same tendency of the microhardness decreasing as the resin thickness increased was observed as shown in table (3). Previous studies reported that the resin hardness at the bottom was significantly different from that at the top when the specimens were 4 to 5 mm thickness this result in agreement with previous studies [18,19]. This is due to the fact that at top surface sufficient light energy reach photoinitior, thus starting the polymerization reaction as light passes through the body of a composite, it is intensity is greatly decreased due to absorption and dispersion of light by filler particles and resin matrix. This decrease results in a gradation of cure causing a decrease in hardness level from the top surface to inwards. This fact explain the difference between top surface and bottom surface hardness for all tested materials and tested curing unites this finding in agreement with previous studies [(20)] .

The bottom/top hardness ratio above 80% has often been used as a minimum acceptable threshold which means in this study the material which bottom/top ratio of 80% and above can be placed and cured properly in the 4 mm bulk in clinical situations as shown in table (7).

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