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Evaluation of the compressive strength of different composite materials using different light curing generations

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Abstract

Background: a new generation of light emitting diodes LED claim that their devices are able to cure dental composite completely with only 3 to 6 seconds according to reciprocal relationship theory between light intensity and curing time.

The aim of the study: to evaluate the effect of different light curing devices and curing protocols on compressive strength of different composite materials.

Material and methods: Two composites brand were used (ceram x universal and beautiful bulk fill), acrylic templates were fill with composite to fabricate 40 samples, 20 for each composite brands, 10 cure with normal curing protocol for 20 seconds for control group while experimental group was cure for 6 seconds using the third generation LED. The samples were tested by universal testing machine Instron to measure the load need to break the sample under compressive force.

Results: The result showed that there was a significant difference between Ceram x universal groups. there was a significant difference between beautiful bulk – fill groups

Conclusion: the compressive strength of different composite brands was lower when using the third generation LED, cream x universal had higher compressive strength than beautiful bulk fill composite.

Keywords: Ceram x universal, beautiful bulk fill, diodes LED

INTRODUCTION

In spite of the curing time for dental composite can be controlled for optimum polymerization, 2 mm composite increment thickness had been suggested by different composites brands to be cure with Variety of light curing unit present now a day [1,2]. Recently many dental company brands improve composite composition to be able to cure completely up to 4 mm thickness, this type of resin base composite call bulk fill. In the same time, light curing unit manufacture developed a new generation of LED which claims that their units are able to cure dental composite completely with few seconds according to the reciprocal relationship between light intensity and curing time if light intensity increase the curing time decrease [2,3,4].

There were many devices can be used for curing resin-based composite: halogen lights, plasma arc, ultraviolet lights, and light emitting diode LED, however, most recent developments were done for LED because of their several advantages over predecessors: light in weight, no need for cooling fan, decrease exposure duration and long duration of service [5,6,7].

There are three LED light curing unit(LUU) generations, the first and second-generations were capable of curing 2 mm thickness of resin-based composite in 20-40 seconds. Third-generation of LED-LCUs claimed that completely cure the whole composite increment (2 mm) with only a few seconds as a result of increasing irradiance outputs [8].

MATERIALS AND METHODS

Fourteen composite resin specimens were constructed from two brands Ceram X universal from Dentsply (nanocomposite) and Beautiful-Bulk Fill Restorative from Shufo (Giomer). Each brand was represented by 20 specimens divided into two groups: a control group (curing time 20 seconds as claimed by the manufacturer's instructions), experimental group (curing time 6 second). The composite resin in the control group was cured with an Xlite II LED curing unit (Flight Dental system, China) which had a 1700-mW/cm2light intensity, while experimental was cured by third generation 6 seconds LED curing unit (Mident.biz, China) with a 2700- mW/cm2 light intensity.

An acrylic cylindrical templates were used for specimen's construction; the templates had central perforation measuring 4mm in diameter and 4mm in height.

For specimen's construction, templates were placed on a glass slab and filled with ceram X universal composite using the incremental technique, and every increment (2 mm thickness) was curing for 20 seconds. The last increment of composites is covered with a dental celluloid strip, and another glass slab was placed resin-based composite, using force against the composite resin template. After 10 seconds, the top glass slab was removed, the celluloid strip was kept in position, and then the final increment was light-cured for 20 seconds for the control group, according to manufacturer instrthe actions. While the experimental group was cured for 6 seconds for each increment using the third generation LED device.

The process was repeated to make samples of Beautiful-Bulk Fill composite from Shufo, but the templates fill completely with single increment and cure for 20 seconds using Xlite II LED curing unit (for the control group) and cure for 6 seconds using the third generationthe LED curing unit (for experimental group). The specimens of composite resin were marked to identify the surface that exposes to light from light curing unit.

Testing procedure

Instron (universal testing machine) was used for testing the compressive strength of all specimens.

Cylindrical indenter with a flat surface was used with **a** crosshead speed of 1.0 mm/min until fracture occurred and then load recorded which represent the compressive strength of the specimen fig (1) (2).

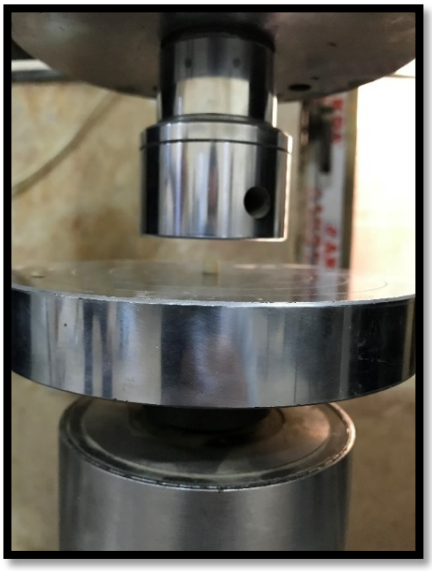

Fig (1) sample on the cell load of Instron

Table 1: Mean, stander deviation, the Maximum and Minimum of compressive strength of two composite brands used in this study

Composite type	Group	Mean	Stander deviation	Minimum	Maximum
Ceramx universal	Control	370 Mpa	25.49	340	400
	Experimental	274 Mpa	20.73	250	300
The Beautiful-Bulk fill	Control	261 Mpa	16.73	240	280
	Experimental	232 MPa	8.36	220	240

Table 2: ANOVA test for ceram X universal brand

	Sum of squares	df	Mean square	f	Sig.
Between Groups	23040	1	23040	42.667	.000
Within Groups	4320	8	540		
Total	27360	9			

Table 3: ANOVA test for beautiful bulk fill brand

	Sum of squares	df	Mean square	f	Sig.
Between Groups	2102.5	1	2102.5	12.0124	.008
Within Groups	1400	8	175		
Total	3502.5	9			

Table 4: ANOVA test between a control group of both composite brands :

	Sum of squares	df	Mean square	f	Sig.
Between Groups	29702.5	1	29702.5	63.876	.000
Within Groups	3720	8	465		
Total	33422.5	9			

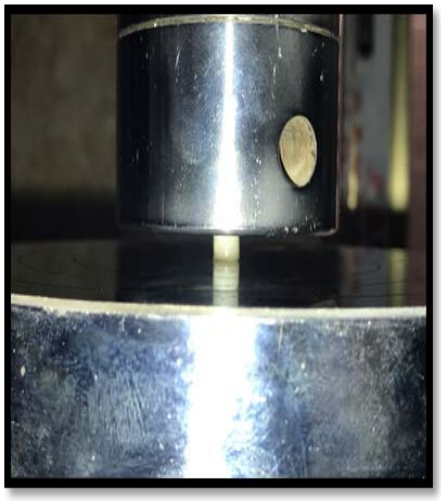

Fig (2): Sample under compressive load

RESULTS

Anova test was done within the groups of each composite types: the result shows that there was significant between Ceram x universal groups table (2). there was a significant difference between beautiful bulk – fill groups table (3).

When using one-way ANOVA to compare the control groups of the two composite brands used in this study, the result shows there was significant differences table (4).

DISCUSSION

Sufficient polymerization was one of the most important factors that affected the physical properties and clinical performance of the resin-based composite. Insufficient composite polymerization leads to a lot of problems: poor physical, mechanical and biological properties, grater stain uptake, a decrease in the retention of composite filling, increased solubility, the risk of pulp sensitivity. all of this problem can have affected the clinical behavior of dental composite. [9 ,10]. Physical and mechanical properties of the dental resin-based composite can be measured using the different testing procedure, for example, flexural strength, surface microhardness, Diametral Tensile Strength, Fracture toughness, Flexural fatigue strength, and compressive strength. In spite of, these tests had been used in studies for comparing the values of mechanical and physical properties among different composite materials rather than light curing units [11, 12], a lot of studies measure the compressive strength to observe the effect of different light curing unit [12,13,27, 32]. The goal of choice the compressive strength test in this study was during the mastication process the majority of chewing forces were compressive in nature. In our study, a control group of Ceram X universal had higher compressive strength values than the experimental group and this may be due to the exposure time of curing experimental group was 6 seconds which not enough for complete polymerization of the composite resin. This agrees with Alpöz et al., which suggest ensuring optimum curing for composite resin, the curing time should be increased to have the maximum compressive strength of resin-based composite materials [18].

Furthermore, ten seconds of curing by light curing unit were insufficient for adequate free radical activation that accompany with light curing throughout the thickness of the whole sample [19]. The degree of conversion can define as the transformation of monomeric carbon-carbon double bonds into polymeric carbon-carbon single bonds [21]. Whenever the degree of conversion is increasing, the physical and mechanical properties of composite improved and had higher measured values. This may be due to increased cross-linkage [22,23, 24]. Additionally, increasing the curing time lead to decrease the percentage of uncured functional groups which resulted in improved mechanical properties of the resin-based composite. Because of the uncured functional groups work as plasticizers, that reducing the mechanical properties [26].

Selig et al. found that curing of resin-based composite for 2.6 seconds and 5.7 seconds did not enough to achieve an acceptable degree of conversion. However, when curing composite for ten, seconds and more can result in 47% and more degree of conversion [20], this can also explain the result of our study that why curing for the 6 seconds show lower compressive strength values.

The result of Beautiful bulk fill brand show that control group had higher compressive load than an experimental group; this could have explained by the degree of conversion of the beautiful bulk-fill composite was depend on curing time more than the power of device [27]. Finally, when comparing the control groups of two composite brands, the result showed that ceram x group significantly higher compressive strength than beautiful bulk fill; and this result might be due to Beautiful Bulk fill contain softer PRG fillers in them [28]. In addition to higher filler content (87 wt%) of Beautiful Bulk-fill composite which result in scattering of light at filler-matrix interface that might impede curing light from penetration of the whole samples thickness and this lead to decrease the depth of cure, decrease in degree of conversion and finally decrease physical and mechanical properties of beautiful bulk-fill composite [30]. Tsujimoto et al. [31] showed that adequate depth of cure for Beautiful Bulk Restorative could be reached on increasing the polymerization time to 40 seconds. In our study, we cure the Beautiful Bulk Restorative for 20 seconds for the control group which may result in incomplete curing of the whole depth of the sample which results in lower compressive strength.

CONCLUSION

Within the limitation of this study, Ceram X universal and beautiful bulk fill composite brands had lower compressive strength when cured with the third generation LED protocol when compared with normal curing protocol. Ceram x universal had higher compressive strength than beautiful bulk fill composite.

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