Differences level of hybrid resin composite's hardness based on post-irradiation time with photoactivated light emitting diode

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ABSTRACT

Introduction: Adequate surface hardness of the resin composites is important to obtain optimum clinical performance of the restoratives in stress dental bearing areas. For light-activated resin composites, polymerization begins when curing light initiates polymerization and continues after the curing light goes off. The degree of conversion and hardness of resin composite is also affected by post-irradiation time. The objective of this study was to evaluate the difference of the hardness hybrid resin composite based on post-irradiation time at 10 minutes, 24 hours, and 7 days with photoactivated light-emitting diode (LED) to obtain the optimum hardness. **Methods**: This study was using a true experimental research method. Thirty samples of hybrid resin composites, disk-shaped of 6 mm in diameter and 2 mm in depth were polymerized by LED LCU at 800mW/cm2 for 20 seconds. The hardness of the resin composite was measured by Vickers Hardness Tester. The result was analyzed statistically with ANOVA. **Results**: There was a significant difference level of hardness among the three groups. Hardness mean value for post-irradiation time at 10 minutes was 56,4 VHN, for post-irradiation time at 24 hours was 65,8 VHN, and for post-irradiation time at 7 days was 60,0 VHN. **Conclusion**: There were differences level of hybrid resin composite's hardness based on the post-irradiation time at 10 minutes, 24 hours, and 7 days with photoactivated LED and the optimum hardness of post-irradiation time at 24 hours.

Keywords: Hardness, hybrid composite, post-irradiation time, LED.

INTRODUCTION

Composite resins have been used in dentistry, specifically tooth conservation as an aesthetic restoration material with good physical and mechanical properties so that they have sufficient strength.[1,2] Light-activated composite composites were first introduced in the 1970s as restoration materials anterior teeth. Since the 1980s with the advancement of mechanical properties of composite resins and light-curing devices composite resins have been used for posterior tooth restorations which can withstand the mastication power.[3-5] Hybrid composites are widely used for posterior dental restorations because they have aesthetic characteristics that are good and able to withstand the mastication power.[3,6,7]

Adequate polymerization is an important factor to obtain optimal physical and mechanical properties of composite resin, one of which is hardness. Adequate composite resin surface hardness is important for obtaining optimal clinical success in restorations in areas that

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receive high loads.[5,8] Hardness is material resistance to indentation and is an important mechanical property that can predict the degree of polymerization of restoration material.9 Resins composites must have a large number of monomers that allow them to convert into polymers during the polymerization reaction.[5]

Light-activated resin composite, polymerization begins when the light initiates polymerization with 75% of the polymerization process occurring in the first 10 minutes and the polymerization reaction continues for about 24 hours.[9,10-12] This is under Tarumi and Leung as well as some existing literature states that the polymerization reaction of activated ray composites continues after irradiation stops. Composites appear to be completely hardened after irradiation is complete, but the polymerization process continues within 24 hours and maximum hardness can be achieved in that period.[7,10-14] The delay of the composite finishing process for 10-15 minutes after the curing process is complete can increase violence by 20-30%.[13]

According to Nogueira[14], Mohamad[10], and Marghalani[8] there is a relationship between the degree of conversion and hardness of the composite resin with the time of polymerization after irradiation. The longer the polymerization time after irradiation, the higher the degree of conversion and hardness of the composite resin. Mohamad[10] and Marghalani[8] stated that there was an increase in hardness and the degree of conversion of composite resins 7 days after irradiation (post-irradiation). This is contrary to Cook who found none Significant changes in the hardness value of light-activated resin composites between day and 12 days. Salako et al in mohamad[10] reported no increase in composite resin hardness measured immediately up to 3 weeks after irradiation. The results of Martos et al found a significant reduction in micro resin composite hardness after 30 days in water storage, but 24 hours storage did not there is a significant change in the value of violence.

The most popular type of light-curing unit (LCU) is the light-emitting diode (LED), which has a wavelength that matches the absorption spectrum of the camphor quinone photoinitiator, as a commonly used photoinitiator.[15] LED curing units are currently available with sufficiently high light intensity ie around 500 to 1400mW / cm^2.[16] Based on the above background the authors are interested in researching differences in the level of hardness of hybrid composite resins based on the time of polymerization after irradiation using LED photoactivation. The purpose of this study was to measure the level of hardness of hybrid composite resins based on the polymerization time of 10 minutes, 24 hours, and 7 days after irradiation using LED photoactivation to obtain optimal hardness.

METHODS

This type of research is pure experimental research. The population in this study is a hybrid type of composite resin material. Population criteria in this study are P60 hybrid type composite resin (3M ESPE), fillers are zirconia/ silica, 61% inorganic filler, 0.01-3.5m, particle size, and contain Bis-GMA, UDMA and Bis resins -EMA. Samples were taken from a population of hybrid type composite resins randomly. Samples amounted to 30 pieces, shaped disk discs with a diameter of 6 mm and a height of 2 mm. The sample was divided into three groups with three different treatments. Each group consisted of 10 samples.

Data on the level of hardness of composite resin which has been calculated the average value for each group are included in the table, then do the calculation of whether there is a difference in the level of hardness of composite resin based on polymerization time after irradiation using LED photoactivation, statistical data analysis with variant analysis (ANOVA) is used. If the test results are significant, then test after ANAVA using the Newman Keuls Range Test (statistical t-test) in pairs.

RESULTS

The study of differences in the level of hardness of hybrid composite resins based on the time of polymerization after irradiation using LED photoactivation, was carried out on samples made with a special mold. The total number of samples was 30 and the samples were divided into 3 groups. Each group consisted of 10 fruits which were given different polymerization time treatments. Group I with polymerization time 10 minutes

Table 1. Data of measurement results of differences in hardness levels of hybrid composite resins based on polymerization time after irradiation using led photoactivation (VHN)

No	Group I	Group II	Group III
	10 minutes	24 hours	2 days
1	54.0	58.2	58.5
2	56.5	68.2	63.8
3	59.5	65.7	58.4
4	58.9	63.7	63.6
5	58.2	67.8	54.4
6	57.0	76.1	54.8
7	53.9	65.0	60.5
8	54.1	64.9	61.7
9	54.3	68.0	63.9
10	54.9	64.4	60.6
average	56.4	65.8	60.0

Table 2. Descriptive statistics measurement of difference in level of hardness of hybrid composite resins based on polymerization time after irradiation using led photoactivation

Mean	N	std. Dev	time
56.4	10	2.341	10 minutes
65.8	10	4.543	24 hours
60.0	10	3.452	7 days
average	**30**	**5.222**	**Total**

after irradiation, group II with polymerization time 24 hours after irradiation, and group III with polymerization time 7 days after irradiation. The test is carried out on the surface of each sample by three adjacent test points and the average value of hardness taken from the three test points. Hardness testing on each sample is done by Vickers Hardness Tester.

The following is the data from the measurement of differences in the level of hardness of hybrid composite resin based on polymerization time after irradiation using LED photoactivation. Table 1. shows the average value of hardness of each sample after testing with the Vickers Hardness Tester.

Table 1 shows the average value of hardness at each polymerization time after irradiation. The average hardness value at the time of polymerization 10 minutes after irradiation was 56.4 VHN, at the time of polymerization 24 hours after irradiation the hardness value was 65.8 VHN,

Table 3. Variant analysis (ANAVA) measurement of differences in hardness levels of hybrid composite resins based on polymerization time after irradiation using led photoactivation

Source	SS	Df	MS	F	p-value
Treatment	448.422	2	224.2110	17.69	1.23E-05
Error	342.246	27	12.6758		
Total	**790.668**	**29**			

Table 4. Newman keuls range test (statistical t test) paired

		10 minutes (I)	24 hours (II)	7 hours (III)
		56.4	**65.8**	**60.0**
I.10 minutes	56.4			
II. 24 hours	65.8	1.66E-05**		
III. 7 days	60.0	0131*	.0050**	

Note: *p <0.05 Is significant, **p <0.01 Is very significant

and at the time of polymerization 7 days after the hardness value was 60.0 VHN.

Table 2 shows descriptive statistics regarding differences in the level of hardness of hybrid composite resins based on the time of polymerization after irradiation using LED photoactivation.

Table 2 shows the average hardness at the time of polymerization 10 minutes after irradiation is 56.4 with a standard deviation of 2.341. The average hardness at the time of polymerization 24 hours after irradiation is 65.8 with a standard deviation of 4.543. The average hardness at the time of polymerization 7 days after irradiation is 60.0 with a standard deviation of 3.452.

Table 3 shows the results of ANAVA analysis for testing the differences in the level of hardness of hybrid composite resins based on polymerization time after irradiation using LED photoactivation. Variant analysis (ANAVA) to test the similarity of strengths of the three groups is shown in the following table:

Table 3 The ANAVA test results above obtained F count for the hardness of hybrid composite resins with three different polymerization times after irradiation of 17.69 which is greater than the F table of 5.49 (99%) or p-value (0.0000123) smaller than α = 1% (significance level of 99%). This shows that the test results are very statistically significant, meaning that the three types of polymerization time treatment after irradiation

on hybrid composite resins give different hardness values of 56.4 (10 minutes), 65.8 (24 hours), and 60, 7 (7 days), thus the hypothesis can be accepted. The results of testing with the ANAVA above are very significant, then to compare in pairs between the three treatments the Newman Keuls Range Test (statistical t test) in pairs (Table 4).

Statistical test t test was carried out after the ANAVA test gave meaningful results. From table 4.4 above it can be concluded that the difference in the results of composite resin hardness between groups I and II, is very significant p = 0.01> 0.0000166, the difference in the results of composite resin hardness between groups I and III, significant p = 0.05> 0, 0131, and differences in the results of composite resin hardness between groups II and III, very significant p = 0.01> 0.005.

DISCUSSION

The results showed that group I, namely the group with polymerization time of 10 minutes after irradiation had an average hardness of 56.4, then group II, namely the group with polymerization time 24 hours after irradiation had the highest average hardness of 65.8, and group III ie the group with a polymerization time of 7 days after irradiation has an average hardness of 60.0.

The results in Table 1 show the average value of composite hardness with polymerization time 24 hours after irradiation (65.8) and 7 days after irradiation (60.0) is higher than the average value of composite hardness with polymerization time 10 minutes after irradiation (56.4). These results indicate the polymerization time after irradiation affects the level of hardness of the composite resin. The longer polymerization time after irradiation results in increased hardness of composite resins with maximum hardness can be achieved within 24 hours. The hardness of composite resins increased after 24 hours and 7 days after irradiation. This is following the statement of Albers[13] and Craig[12] who stated that maximum composite hardness was achieved within 24 hours. Mohamad[10] and Marghalani[8] stated that there was an increase in hardness and degree of conversion of composite resin in 24 hours and 7 days after irradiation (post-irradiation).

Increased hardness of composites 24 hours and 7 days after irradiation can occur because the polymerization process begins when the composite is exposed to light (irradiation polymerization) and continues for 24 hours even 7 days after irradiation (post-irradiation polymerization). At the time of polymerization, there is a breakdown of the monomeric aliphatic carbon double bond into a single carbon polymer bond. The degree of conversion is the percentage of the number of monomers that convert to polymers. The degree of conversion is a parameter that shows the physical and mechanical properties of composite resins. The physical and mechanical properties of composites tend to increase with an increase in the degree of conversion. The polymerization reaction continues to increase the degree of conversion so that the hardness of the composite increases. The degree of conversion is used to determine the degree of polymerization of composites with the mechanical properties, biocompatibility, and color stability of composites. The higher degree of conversion will result in higher surface hardness, flexural strength, modulus of flexibility, resistance to fracture, tensile strength, and resistance to chewing power.[8,10,17,18]

In this study, the average value of composite hardness with polymerization time 24 hours and 7 days after irradiation (65.8 and 60.0) increased compared to the average value of composite hardness with polymerization time 10 minutes after irradiation (56.4). The average value of composite hardness with 7 days polymerization time (60.0) increased compared to the average value of composite hardness with polymerization time 10 minutes after irradiation (56.4) but decreased compared to the polymerization time 24 hours after irradiation (65, 8). This can occur because hydrolytic degradation due to water absorption and solubility of the composite affects the hardness of the composite resin. The surface hardness of the composite resin can be significantly affected by water absorption and contact time with the liquid environment. Composite resins exposed to water will experience degradation associated with the degradation of filler particles, the polymer matrix becomes weak, or the surface of the matrix-filler is released. One of the physical properties of composites, namely water absorption, and solubility, causes the hydrolytic degradation of filler particles resulting in decreased composite hardness.

This hydrolytic degradation occurs mainly due to the accumulation of water between the surface of the filler-matrix which causes the release of inorganic particles or associated with superficial fissures due to corrosion processes. Dissolution of composite resin components, especially inorganic ions or filler particles, can occur in short or long periods. Storage of composites in water, saliva, or alcohol for 4 weeks significantly decreases the mechanical properties of composites when compared to storage for 24 hours. stored in a liquid environment.[19] The mechanism of hydrolytic degradation occurs when filler particles have metal ions in their composition. The occurrence of this mechanism can be explained because some ions in filler particles, such as zinc and barium are electropositive and tend to react with water. The dissolution of these components into water changes the balance of the silica chain. The penetration of hydrogen ions from water causes an increase in the concentration of hydrogen ions, damaging the siloxane (Si-O-Si) bonds in the silica chain and hydrolysis triggering the release of filler particles increasing composite mass loss.[19,20,41]

CONCLUSION

There is a difference in the level of hardness of hybrid composite resins based on the polymerization time of 10 minutes, 24 hours, and 7 days after irradiation using LED photoactivation and the highest hardness value is at the time of polymerization 24 hours after irradiation.

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