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Original Article

Hardness of composite resin polymerized with different light-curing units

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Abstract

Introduction: The degree of polymerization depends on the type of light-curing unit. The aim of this study was to compare the hardness of composite resin cured by LED and Halogen light curing units.

Methods: In this experimental study, 20 cylindrical samples of Tetric Ceram composite were prepared. Half of them were cured with Ultralume 2 LED and the other half with Astralis 7 Halogen light curing unit. In the depths of 0,1,2 and 3 mm from surface, one point in peripheral and one point in central portion were marked ,then the hardness of these points was measured by Vickers test . The data was analyzed by a pvalue less than 0.05 considered as significant.

Results: The mean hardness of samples cured by LED was more than halogen group in different depths and this difference was statistically significant in peripheral points (p=.048) but this was not significant in central points (p=0.644). The mean hardness in both groups had a decreasing trend from surface to the deep parts in central and peripheral parts and this was more in the central parts.

Conclusions: Composites cured by LED light curing unit showed more hardness in similar depths, besides the hardness of composites in central parts is more than the peripheral ones in both groups.

Keywords: Dental composites, LED, hardness, Halogen.

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Introduction

In recent years, with the increase in esthetic demand, composite resin has become the material of choice for tooth restoration. These restorative materials ranged from self to light curing (1). Many attempts had been done to improve their physical and mechanical properties. Improved polymerization results in improved physical and mechanical properties such as hardness. Surface hardness that is defined as resistance to surface indentation is an indirect method for measuring polymerization degree. The comparison between the deep and surface hardness yields valuable information (2, 3). Since, the polymerization of light curing resins depends on source and properties of light source, improvement in light curing units can be a method for better properties of final restoration (2). Halogen lamps have been widely used as the source of light curing units since the 1970s. These lamps have many disadvantages such as emitting large amounts of undesirable wavelengths which cause heating of resin and tooth. It also causes decreasing the emitting light with time because of filter degradation and limited life time of the lamp that is 40-100 hours. Many attempts had been done to find an appropriate substitute, so LED light curing units were introduced. These units

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are gallium nitride semiconductor to emit blue light with the spectral output between 450 and 490 nm. Since the maximum absorption of camphorquinone (photo initiator in composites) is in the same range, they do not require a filter.

It was reported that their life time is more than 10000 hours and even some of them work on battery. They do not produce as much heat as halogen devices, so they don't need fan and are more resistant to stroke (2, 4). There are multiple reports on more polymerization and better dimensional stability with these units compared to halogens (5, 6). Yap et al. compared surface hardness of composite resins cured with new high power light curing unit (Elipar Freelight 2) and those with high power and conventional halogen LED. The results showed that the new LED cured resin composites in half time of conventional and high power halogen with the same quality. Park et al. obtained similar results (7, 8). However some investigations showed that LED light curing devices result in improper composites' quality compared to halogen units. But these units were the first generation which had low power light output. Kurachi et al. compared hardness of composites cured with the first generation of LED with light output of 79 mw/cm2 and those with halogen and showed less hardness in LED group (9). Soh et al. reported similar results about the first generation of LED units (4).

Since studies about composite polymerization using LED light curing units and their effect on hardness showed different results, and due to the vast diversity of different LED units, this study tried to evaluate the efficiency of one LED and Halogen light curing units.

Methods

This in vitro study was done using A3 Tetric Ceram (Vivadent, Liechtenstein) composite in two groups of 10 samples. Composite samples were made in metal molds with internal diameter of 8 mm and depth of 5 mm. The sample surfaces were covered with glass lamels. In group 1, the samples were cured by Ultralume 2 LED unit (Ultradent, USA) with 560 mv/cm^2 for 40 s. In group 2, curing was done using low power intensity of Astralis 7 halogen unit with 400 mv/cm^2 for 60 s as control. There was no distance between the tip of light curing unit and glass lamels. Then all samples were embedded in epoxy resin and cut from their center. The surfaces were polished with 600, 800, 1200 grit silicon carbide polishing disks in three stages.

Then Vickers hardness was done in depth of 0, 1, 2, 3 mm and 2 points in central and peripheral. This test was done to compare the hardness between central and peripheral areas and between the samples cured with LED and halogen units in different depths. Vickers hardness test was done in Mashhad Mechanic laboratory. The testing machine pressed 200 gr force for 10 seconds. In each sample, the test was done in 8 points relating to the hardness of different areas.

The data was analyzed by SPSS software. After evaluating the variables with Kolmogorov-Smirnov test, the comparison between the mean hardness in different depths in two groups was done with Repeated Measurement, independent t-test and Paired T-test with significant level of 0.05.

Results

The results showed that mean hardness of all depths of peripheral parts in LED group was higher than halogen group and this difference was statistically significant (p=0.048) but the difference was not significant in central parts (p=0.644) (tables 1 and 2).

Despite the higher hardness of halogen group in the depths of 1 and 2 mm of central area than LED group, the results showed that hardness of LED group in other depths was significantly higher than halogen group (table 1). To compare hardness of central and peripheral parts, the hardness of each depth in each group was evaluated. The results showed that the difference was significant in some depths (tables 1 and 2).

In composites cured with LED unit, the mean hardness decreased from surface to deep points and this decreasing trend was statistically significant in central (p=0.000) but not significant in peripheral points (p=0.542). In composites cured with halogen unit, the mean hardness of central and peripheral part decreased from surface to deep points and this trend was statistically significant (p=0.000 and p=0.024). Besides, the results showed that the hardness of central was more than the peripheral parts in both groups and it was statistically significant in most depths. (LED p=.004, p=.049, Halogen p=.042, p=.047).

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Table 1. Mean and standard deviation of specimens hardness in central points

Depth Group	0 mm Mean±SD	1mm Mean±SD	2mm Mean±SD	3mm Mean±SD
LED	93.93±11.99	83.37±9.41	77.22±11.15	75.33±10.62
Halogen	84.51±9.16	83.59±44.85	77.59±29.43	69.06±16.75
P-value	0.064	0.988	0.971	0.331

p=0.644

Table 2. Mean and standard deviation of specimens hardness in peripheral points

Depth Group	0 mm Mean±SD	1mm Mean±SD	2mm Mean±Sd	3mm Mean±SD
LED	81.11±14.81	77.08±7.24	70.05±16.93	62.45±15.25
Halogen	71.52±8.23	64.83±7.03	62.10±4.88	57.05±6.46
P-value	0.090	0.001	0.149	0.316

p=0.048

Discussion

According to the results of this study, in LED group, the hardness of resin composites in peripheral parts of all depths was significantly more than the halogen group but this difference was not statistically significant in central parts. According to these findings, the efficiency of LED unit is higher than halogen unit. These results are in consistent with many studies. Miles et al. showed that the efficiency of LED unit is more than halogen unit in view of polymerization and hardness (1). Rahiotis et al. concluded that LED units are better than the Halogen ones in curing efficiency, marginal gap, degree of conversion and curing depth (10).

Besides most studies were in unanimity that LED units have more curing depth and produce less heat (5-8). But some studies reported different results. Kurachi et al. compared the hardness of composite cured with LED and conventional halogen .The hardness of composites cured with LED unit with a light output of 279 mw/cm^2 was lower than those cured with halogen unit with a light output of 475 mw/cm^2 with the same curing time.

Soh et al. compared LED and halogen and found that the hardness of samples in halogen group was significantly more. In their study, light output of both groups was 200 mw/cm^2 but the exposure time was 10 s for LED and 40 s for halogen (4). The difference between the results of current study to the other ones is because of the difference in light output and exposure time. In Kurachi et al. and Soh et al. studies, the efficiency of LED unit was lower than Halogen and it may be because of lower light output in Kurachi's study and less exposure time in Soh's study. In our study, the light output of halogen and LED was 400 mw/cm^2 and 560 mw/cm^2 and the exposure time was 60 s and 40 s, respectively. The different times were chosen to equal emitting energy. Moreover, the exposure time of 40 s and 60 s are clinically acceptable.

The results of some studies showed that the mechanical properties and hardness of LED cured composites were similar to halogen and it could confirm the results of this study (11). Alaghemand et al. compared the wear of LED cured composites with halogen ones and reported that the wear in halogen group was more but the difference was not significant (12). According to the results of current study, in both groups and parts; central and peripheral, hardness was decreased from surface to depth and this indicated that in deep parts, light infiltration and polymerization and hardness would be decreased.

Comparing the hardness between central and peripheral parts in each group and each depth showed that the hardness in central was more than peripheral areas, because the highest light intensity was emitted from the center of the tip and this was similar for both units. On the other hand, it might be because of light reflection from the circumference of mold to the center and more hardening of the center. This term could be equivalent to metal matrix band in clinic.

Conclusion: LED light curing unit produce more hardness in similar depth of composite compared to Halogen unit

1. The hardness of composites in central is more than the peripheral areas in both groups.

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Conflict of interest: None

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