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Original Article

A comparative study of the effects of QTH and LED light curing units on the surface hardness of colored compomer and Hybrid composites

Effat Khodadadi(DDS)[1] Nastaran Shamsi[2], Soraya Khafri(PhD)[3], Homayoun Alaghehmand(DDS)[4]✉

1. Assistant Professor, Department of Pedodontics, Faculty of Dentistry, Babol University of Medical Sciences, Babol-Iran.
2. Dental Student, Faculty of Dentistry, Babol University of Medical Sciences, Babol-Iran.
3. Assistant Professor, Department of Social Medicine and Health, Faculty of Medicine, Babol University of Medical Sciences, Babol-Iran.
4. Associat Professor, Dental Materials Research Center, Department of Operative Dentistry, Faculty of Dentistry, Babol University of Medical Sciences, Babol-Iran.

✉**Corresponding Author:** Homayoun Alaghehmand, Faculty of Dentistry, Babol University of Medical Sciences. Babol-Iran.
Email: halagheh@yahoo.com **Tel: +98112291408-9**

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Abstract

Introduction: One factor affecting the degree of polymerization is the type of light-curing device. The aim of this study was to compare the effects of LED and QTH light curing units on the surface hardness of composite and compomer.

Materials &Methods: In this experimental study, 30 samples of composite and compomer were divided into 3 groups of 10 each. One-half of the subgroups in each group were cured with LED and the other half with Halogen light curing units (LCUs). 49 points on the surface were marked and then the hardness of these points was measured by using Vickers hardness test.

Results: The mean hardness of composites cured by using LED was more than the Halogen group but in compomer it was reversed and this difference was statistically significant ($p<0.001$). Z 250 composite had the highest level of hardness and the lowest hardness was related to the Heliomolar composite and had significant difference ($p<0.001$).

Conclusion: In the present study, the results indicated that LED light curing unit had great effect on the hardness of composites but in compomer, the QTH showed a better result.

Keywords: Composite resins, Compomer, Curing lights dental, Hardness

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بررسی مقایسه ای اثر دستگاه های لایت کیور LED و QTH بر میزان سختی سطحی کامپومر رنگی وکامپوزیت های هیبرید

عفت خدادادی، نسترن شمسی جامخانه، ثریا خفری، همایون علاقه مند*

چکیده

مقدمه: یکی از فاکتورهایی که بر درجه پلیمریزاسیون تاثیر می گذارد، نوع دستگاه لایت کیور است. هدف از این مطالعه مقایسه اثر دستگاه های لایت کیور LED و QTH برمیزان سختی سطحی کامپوزیت و کامپومر است.

مواد و روش ها: در این مطالعه آزمایشگاهی، ۳۰ نمونه از کامپوزیت و کامپومر به ۳ گروه ۱۰ تایی تقسیم شدند. نیمی از آنها با دستگاه LED و نیمی دیگر با Astralis 7 Halogen کیور شدند. ۴۹ نقطه در سطح مشخص شدند.سپس سختی این نقاط بوسیله دستگاه سختی سنجی ویکرز اندازه گیری شد.

یافته ها: میانگین سختی کامپوزیت های کیورشده با LED بیشتر از QTH بود، اما در کامپومر نتیجه ای بالعکس بدست آمد که از لحاظ آماری تفاوت معناداری داشت. کامپوزیت Z250 بطور معناداری بیشترین سختی را داشت و کمترین سختی مربوط به کامپوزیت Heliomolar بود.

نتیجه گیری: نتایج این مطالعه نشان داد که LED اثر بیشتری بر سختی کامپوزیت ها داشت اما در کامپومر QTH نتایج بهتری نشان داد.

واژگان کلیدی: کامپوزیت رزین،کامپومر، لایت کیور دندانی، سختی

Introduction

There has been a rapid development of new adhesive restorative materials that can restore the color and features of natural teeth. [1,2] Light-cured resin composites have been widely used because they are conservative and more esthetic technique and have many advantages in comparison with self-cure composites. [1- 4] For acceptable treatment in children, different restorative materials made in different colors called compomers are widely used for primary teeth. [5,6] Compomers are composites with some glass ionomer components. Most of them are light cured materials so it is very easy to use them and they become popular, because their functional properties are desirable and have some advantages as ability to release fluoride, minimum steps required to place and esthetic as composites. Colored compomers can be produced by adding a small amount of glitter particles (mainly silicates form kali) to conventional compomers to produce materials with pink, green, blue, silver, lemon and gold shades.[7] Because of the color and the attractiveness of compomers, the children are encouraged to cooperate more and make it possible to choose different colors during the treatment and have less stress, fear and impatience.[5,6] The majority of dental equipment that can be caused esthetic restorations is light curing units. Today, there are four main sources for polymerization of light composites: Quartz-tungsten-halogen (QTH), Plasma Arc (PAC), L/ight emitting diode (LED), Argon ion laser. Each of them has some advantages and disadvantages that can affect the degree of polymerization of light resin composite.[1, 8, 9] The most common light curing units, which are used for the polymerization of resin composites, are Halogen units and their output light intensity is 400_800mw/cm². Despite the low costs, there are some disadvantages: limited curing depth, long curing time and the output light intensity decreases with time. It seems that the degree of polymerization can be improved with increasing light intensity. Therefore, light units with high intensity were introduced such as argon ion laser with a light intensity output up to 2000mw/cm².It was reported that

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it speeded up polymerization but caused high temperature on the tip of the light curing unit.[1,10-12]

Due to these limitations, some studies have been assessed using the LED. Light intensity output of previous LED has been about 300mw/cm², but the new models of LED have high light output intensity. LED lamps have the most photo-polymerization effect. LEDs need lower energy consumption in comparison to QTH and they do not need any external cooling part, thousand-hour shelf life without decreasing light intensity, smaller units, wireless mode and less heat. According to the mentioned advantages, today LED light curing units are widely accepted. [1, 13]

There are several methods for evaluating the hardness of composite resin and the most common is Vickers microhardness device that is an indirect method to determine the degree of monomer conversion and composite polymerization. [14]

Since the physical and mechanical properties of composites are related to the amount of polymerization and the researchers always face to new composites and colored compomers that are already entered and no study has been done to assess the amount of their surface hardness yet, so in this study, the researchers want to consider the effects of different light curing units on the amount of surface hardness of composites and compomers and compare them.

Methods

Two types of resin composites with high [filtek Z 250 (3M, USA) (group 1)] and low [Heliomolar (colten, Germany) (group 2)] surface hardness [15] with Twinky star compomer (Voco_Germany) (group 3) with silver shade and two light curing units: LED valo(ultradent, USA) and Astralis 7 QTH (ivocolar vivadent , Austria) (table 1,2) were compared in this experimental study . Composites had A2 shade.

30 samples were prepared for three of ten-sample groups. All the samples were placed in the Teflon molds with length and width of 4mm and thickness of 1mm.The samples were protected to prevent air as they impact at both sides of the mold with a glass slide and the pressure was applied to extrude the excess material. Jig molds were made from putty to ensure perfect positioning and pick up. In each group of composites and compomers, 5 samples were cured by Astralis 7 QTH (ivocolar vivadent, Austria) and 5 samples were also cured using LED valo (ultradent, USA). The exposure times were chosen for QTH 40s and LED 20s based on the manufacturers' recommendations. A halogen with an output irradiance of 400 mw/cm²and LED with 800 mw/cm² were used for curing process. Then the samples were stored for 24 hours in a dark place, water and room temperature for the completion of polymerization. All samples were placed in the acryl and mounted. The surface of the materials was polished using a 400, 800, 1000, 1500, 2000, 2500 grit silicon carbide paper. The microhardness of the surface in 49 points with intervals of 0.5mm was determined by using Vickers microhardness device that the load used was 500 gram for 10 second (figure 1). The data were statistically analyzed using SPSS 20 software test and one-way ANOVA, two-way analysis of variance and multiple comparisons Scheffe. The level of significance was considered $p<0.05$.

Table1. Utilized light curing units

Light curing unit	Intensity (mw/cm²)	Time (second)	Energy output (mj/cm²)
LED VALO (ultradent USA)	800	20	16000
QTH Astralis 7 (Ivocolar Vivadent,Austria)	400	40	16000

Table2. Utilized materials

Product name	Manufacturer	Composition	Shade
Composite Filtek z250	3M/ESPE,USA	Bis GMA, UDMA, Bis EMA	A2
Compomer twinky star	VOCO, Cuxhaven, Germany	BisGMA, BHT, TEGDMA, durethane, dimethacrylate	silver
Composite Heliomolar	Coltene, Germany	BIS GMA, Urethane dimethacrylate, Decandiol dimethacrylate, Silicon dioxide, Y terbium trifluoride	A2

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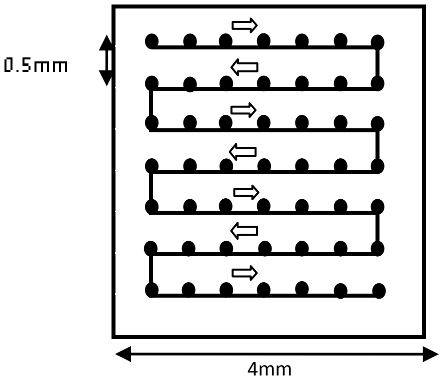

Figure1. The schematic image of pointing method to measure the hardness of places is defined in 49 points with intervals of 0.5 mm.

Results

Two-way analysis of variance showed that the hardness of two units, 3 types of materials and different materials in different units had significant difference at the level of α=0.05 (Table 3). One-way (ANOVA) test also showed that Z250 composite had significantly the highest hardness and Heliomolar composite had the lowest hardness (figure 2).

According to the type of units, LED significantly showed higher hardness in Z250 composite and Heliomolar composite compared to QTH, but this result was reversed in the Twinky star compomer (figure 2).

Table3. Comparison the amount of hardness of different materials in different units

P value	Twinky star	Heliomolar	Z250	Composite/unit
<0.001	(c) 1098.033±154.1772	(b) 767.670±1156245	(a) 1838.804±285.1994	LED
<0.001	(c) 1232.214±163.5166	(b) 740.765±152.4801	(a) 1578.867±311.6296	QTH
	<0.001	0.028	<0.001	P Value

- The different letters in each row indicate the significant difference in 0.05
- The numbers in the table are Mean±SD

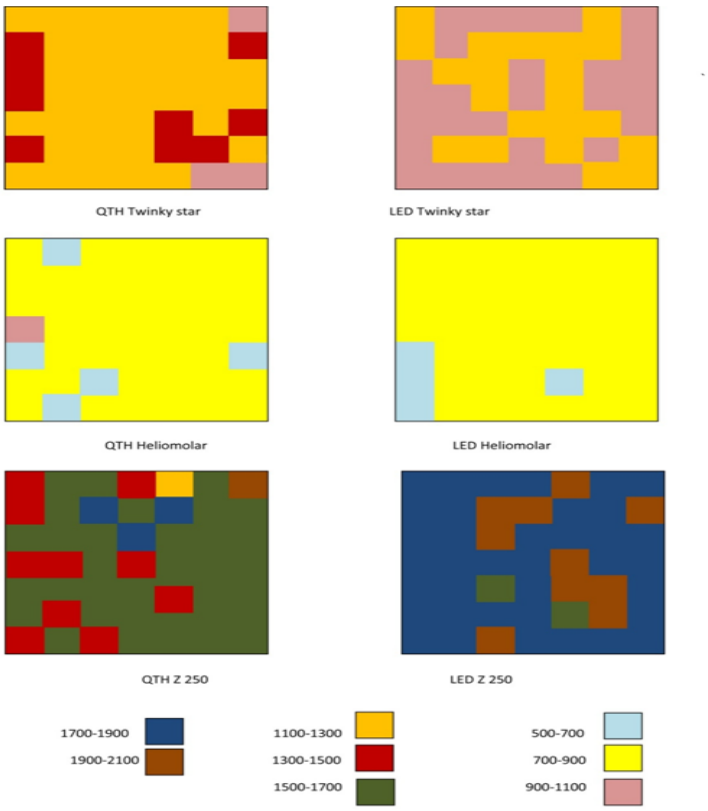

Figure2. The color schematic image consider the hardness of Composites and Compomers.

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Discussion

The result showed the significant difference in the hardness of two units, three materials and different materials in different units. Hardness is defined as the resistance to permanent indentation which correlates with the degree of monomer conversion. [16] The lower degree of monomer conversion corresponds to the inferior mechanical properties of material [17] and there are different techniques to evaluate it. Vickers microhardness device was used in this study.

In current study, LED light curing unit produced greater hardness in group 1 and group 2 than QTH, but it was reversed in group 3. According to the studies of Safarcherati et al in 2009[18] and Vaezi in 2012[19] and Yaman et al in 2011[20] on the hardness of composites by LED and QTH light curing units, there was a significant difference between these two units which was similar to the results of the present study.

By considering the proximity of emitted wave spectrum of LED to the absorbing spectrum of comphorquinone, LED can produce higher hardness than QTH. The most common initiator used in light cure composite materials is comphorquinone that its absorbing spectrum is around 468nm, but it is possible to use the other photo initiators in composites activated in lower wave spectrum.

In the current study, the hardness of composites was higher when they were cured with LED than QTH, which was in contrast to the results of Polydorou et al. in 2008 .They related the better result of QTH to the noticeable heat produced by using light unit. [10] Okte et al. in 2005 reported that there was no significant difference between LED and QTH light curing units on hardness of two compomers in 40 seconds which was different from the outcomes of this study. They found that it might be due to the LED properties and material type. [16] Because of high intensity of LED light output compared to the QTH in this article, some components of compomer may not completely polymerized due to the activation at lower wavelengths therefore they caused the lower hardness.

Group 1 and group 2 had the highest and lowest surface hardness, respectively in this study that was in accordance with the study carried out by Price et al. in 2009.[21] The hardness of composites is certainly related to their composition. Since the Z250 composite was microhybrid and had a comphorquinone and high percentage of filler, it seemed that these led to more hardness. Heliomolar composite is microfill with high radiopacity thus light scattering occurs and the reduction in the intensity of the light beam can reduce the hardness of this composite. [22,23]

Koupis et al. in 2006 evaluated the relative curing degree of polyacid-modified and conventional resin composite, they found that the compomer had less hardness than Z 250 composite which was similar to our finding. They related it to the type of materials. Hybrid resin composites have higher light transmission coefficient and hence they have a greater curing degree compared to microfilled resin composite, also compomers consist of some additional specific monomers and a rather easily degradable (usually opaque) aluminosilica glass. It is expected that these modifications can affect the curing degree of compomers compared to conventional resin composites. [24] According to Hwang et al. in 2007, the transmittance spectral distribution can be influenced by the glittering effect. Glittering components contain irregular shapes and sizes that can reduce the hardness of material, so they can reduce the hardness of compomer, too. [7]

The color of compomer can also affect light transmission with the degree of polymerization conversion. Koupis et al. in 2006 reported that the darker color reduces the degree of curing material, so it can be effective in the reduction of compomers' hardness. It is obvious that this statement needs more investigation. [24] Different factors such as light source intensity, wavelength, exposure duration, size and type and content of fillers, location and orientation of the tip of the source and color have influence on polymerization of the light curing material. [16]

Because compomer is a new material and no study has been done on its surface hardness, it seems that the causes of its difference with the composites studied in this article, considering the identical exposure time and color of the material were the factors mentioned above that had affected its polymerization. In our study, compomer cured with QTH had high hardness than LED. By considering the disadvantages of QTH, it requires further studies.

Conclusion

The hardness of compomer is lower than that of Z 250 composite, but on the other hand, the compomer has variety of different colors and brightness and more hardness than Heliomolar composite. It can be said that compomer may be a useful material for the restoration of primary teeth in children. LED light cure unit had the greatest impact on the surface hardness of composite. Although QTH in compomer had better results, further studies are needed.

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Conflict of interest: There was no conflict of interest.

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