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Comparison of Surface Hardness of Various Shades of Twinky Star Colored Compomer Light-cured with QTH and LED Units

Effat Khodadadi[1], Soraya Khafri[2], Mahdiyeh Aziznezhad[3]

[1] DDS. Assistant Professor, Department of Pedodontics, Faculty of Dentistry, Babol University of Medical science, Babol, Iran
[2] Ph.D., Assistant Professor, Department of Biostatistics and Epidemiology, Faculty of Medicine, Babol University of Medical Sciences, Babol, Iran
[3] Postgraduate Student, Department of Pedodontics, Faculty of Dentistry, Babol University of Medical Science, Babol, Iran

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Abstract

Introduction: Colored compomers are a group of restorative materials that were introduced in 2002 to repair primary teeth, and they provide attractive color and ease of use in pediatric dentistry. The aim of this study was to evaluate the effect of QTH and LED light-curing units on the surface hardness of different colors of Twinky Star compomers.

Methods: In this experimental study, a composite resin (Z250, 3M, and USA), an ionosit compomer (DMG, Germany) with A3 shade and 8 different Twinky Star colored compomer (Voco, Germany) samples were used. In all, 100 samples were prepared with 10 samples in each group, i.e., 10 Z250 composite resin, 10 ionosit compomers, and 10 Twinky Star compomer samples of each color. The samples were prepared in a 4×4-mm Teflon mold. Half of the samples were light-cured with QTH and the other half with LED units. Then, the surface microhardness was measured by Vickers hardness test. The data were analyzed with IBM-SPSS version 22, using the t-test and ANOVA.

Results: Two-way ANOVA showed that the mean surface hardness of the compomer samples cured with the QTH unit was significantly higher than that cured with the LED unit ($p < 0.001$). In each curing unit, surface hardness of some materials exhibited significant differences with the highest hardness being observed in the Z250 composite resin (650.35 ± 56.320) and the lowest hardness being detected in the ionosit compomers (461.10 ± 96.170). One-way ANOVA also showed that, among the different colors of the Twinky Star compomer, the lowest hardness with both units (QTH and LED) was observed in the gold color (214.32 ± 22.026 and 175.116 ± 15.918, respectively).

Conclusion: The colored compomer and the type of light-curing unit affected the microhardnesses of the surfaces. Different colors of Twinky Star compomers exhibited different surface microhardnesses.

Keywords: Colored compomer, Surface hardness, QTH, LED

1. Introduction

Since the need for cosmetic dentistry has increased significantly, rapid progress has been made in adhesive restorative materials that can save the color and features of natural teeth (1, 2). Light-cured composite resins are restorative materials that are used extensively in the restoration of anterior and posterior teeth due to their beauty and conservative technique (1-4). For acceptable treatment in children, other restorative materials, called compomers, are used extensively for primary teeth, and they are available in different colors. Compomers are polyacid-modified composite resins that were introduced in 1993. Compomers contain 20% glass-ionomer cements in combination with 20% photo-polymerized resin components (5). Twinky Star (Voko) is a colored, light-cured, radiopaque compomer with a glittering effect for tooth restoration. Unlike the general shading system of dental

Corresponding author:
Mahdiyeh Aziznezhad, Department of Pedodontics, Faculty of Dentistry, Babol University of Medical science, Babol, Iran. Tel: +98.11132258001, Email: mahdiyeaziznezhad@gmail.com
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restorative materials, the products of this Company include various colors, i.e., blue, silver, pink, green, lemon, and gold. The use of attractive and glittering colors may attract the attention of children and therefore result in their collaboration during the dental treatment (6). In addition, the choice of different colors by children can have a good effect on their fear and impatience during treatment and make them more willing to maintain their oral hygiene (7). Compomers' advantages include the ability to release fluoride, their beauty, their ease of use, and their excellent biocompatibility (8, 9). Even though compomers are able to release fluoride, it should not be taken for granted, and its anti-cariogenic properties are questionable (10, 11). Compomers, like composite resins, contain a light-activated ingredient, dimethacrylate. The majority of light-cured dental materials contain photoinitiators, such as camphorquinone, with a light absorption peak at 470 nm (6). It is essential to use a suitable light-cured tool for polymerization of resin materials; studies have shown that the amount of composite resin polymerization is related to its biological and physicochemical characteristics (12). The most common light-curing units used for the polymerization of composite resins are Quartz-Tungestan-Halogen units (QTH), which are the gold standard of curing with an output intensity of 400-2800 mW/cm2. The advantages of this device include its low cost and wide range of radiation, and its disadvantages can be the limited depth of cure, long exposure time, and reduced light intensity over time (1, 2, 13, 14). To overcome such problems with QTH units, light-emitting solid-state diodes (LEDs) have been used to cure composite resins. These devices use the semiconductor, indium gallium nitride, which produces a blue light and a narrow range with a maximum radiant point of 470 nm (450-490) (15-18). The advantages of these devices include reduced curing time and a lamp life up to 10,000 hours. In addition, these devices use minimum energy; they are light and portable, and they have an ergonomic design and are resistant to shock and vibration. They use semiconductor doping instead of a halogen incandescent filament, so they have low heat and do not need a fan (19-22). When the main photoinitiator system of a composite resin is not camphorquinone, the activation of the initiator system, which has a light absorption beyond the LED wavelength, is not carried out effectively. Since manufacturers do not mention the initiator specifications used in their products, it is difficult to predict the proper curing of all kinds of composite resins (17, 18, 23). Among the methods used to evaluate the resin polymerization technique are the scraping test and the hardness test. Surface hardness means resistance to surface indentation, and it is an indirect method to assess the degree of polymerization (12). A few studies have been conducted on colored compomers; previous studies, including studies by Vandenbulcke and Atabak in 2010 and Jafari in 2014, have shown significant differences in the depth of curing between different colors of compomers (7, 24, 25). Vandenbulcke compared the depth of curing of Twinky Star colored compomers and showed differences in the depth of curing between different colors of compomers, with blue having the maximum depth of curing. Atabak studied the degree of conversion in colored compomers under different curing times and concluded that the degrees of conversion of different colors are different under the same curing time. Given the novelty of this material and the lack of information available and also the use of these substances in primary teeth (colored material), further research is necessary in this regard. Since the mechanical properties of composite resins depend on their degree of polymerization, the aim of this study was to evaluate the effect of QTH and LED curing units on the surface hardness of different colors of compomers and to compare them with hybrid composite resins and ionosit compomer.

2. Material and methods

In this experimental study, Z250 composite resin (3M, USA) and ionosit compomer (DMG, Germany) with A3 shade were selected, and eight different colors of Twinky Star compomer (Voco, Germany) were used. Valo LED (Ultradent, USA) and Astralis 7 QTH (Ivocolar Vivadent, Austria) light-curing units were used for polymerization. In all, 100 samples were prepared, i.e., 10 Z250 composite resin, 10 ionosit compomer, and 10 Twinky Star compomer of each color. The samples were divided into two groups (50 samples); 50 samples were cured with LED and the other 50 were cured with QTH light-curing units. In each case, 5 points were specified for testing surface hardness. The samples were prepared in a 4×4-mm Teflon mold and then protected in a celluloid tape in order to prevent polymerization from the air. Next, they were compressed with a glass slab to remove excess composite resin and the light-conducting tip was placed in contact with the glass plate in order to have a standard status for all the samples in terms of the distance between composite resin and compomer and the tip of the device. In each composite resin and compomer group, five samples were light-cured with Astralis 7 QTH, and five samples were cured with Valo LED light-curing units. According to the manufacturers' instructions, the exposure times for QTH and LED units were 40 and 20 seconds, respectively. The light intensity was checked with a hand-held digital radiometer (Dental Hilux Curing Light Meter, Dental Benlioglu, Inc., Ankara, Turkey) before the light-curing procedure. Then, the samples were stored in water for 24 hours in the dark at room temperature to complete the polymerization of composite resin. All of the samples were placed in epoxy resin. The surfaces of the composite resin and the compomer samples were made completely smooth using 400-, 800-, 1000-, 1500-, 2000-, and 2500-

grit silicon carbide papers. Then, the hardness of the surface was measured at 0.5-mm distances on five points on a 4×4-mm surface area with a 500-g force for 10 seconds with the Vickers hardness test (34). A mean Vickers hardness number (VHN) of each sample was calculated. Mean values and standard deviations of microhardness data were calculated using IBM-SPSS version 22. The data were analyzed statistically among the composite resins as well as among the light sources using two-way ANOVA. In cases in which significant differences were present, one-way ANOVA and the post hoc Tukey tests were used to examine pair-wise differences at a significance level of 0.05.

3. Results

The means and standard deviations of the VHN values of surfaces obtained after polymerization of composite resins with each of the two light-curing units are shown in Table 1. Two-way ANOVA showed that hardness values of two units and 10 different groups of materials were significantly different at the $\alpha = 0.05$ level (Table 1). In each device, the differences between some groups were significant. In the QTH light-curing unit, VHN from the maximum to the minimum was as follows: Z250 composite resin > compomer orange > lemon > pink > blue > silver > green > gold > berry > ionosit. In the LED light-curing unit, VHN from the maximum to the minimum was as follows: Z250 composite resin > compomer pink > green > orange > lemon > blue > silver > berry > gold > ionosit (Table 1). One-way ANOVA showed that, among the types of composite resin and compomers, regardless of the type of light-curing unit, the difference was totally significant ($p < 0.001$). The highest hardness was observed in the Z250 composite resin, and the least hardness was detected in the ionosit compomer (Table 1). The results of the t-test showed that the difference between the two types of light-curing units was significant in terms of surface hardness of composite resin and compomer, irrespective of the type of composite resin and compomer. Hardness was significantly higher with the use of QTH unit compared to the LED unit ($p < 0.001$) (Table 1). One-way ANOVA also showed that the difference between the eight different colors of the Twinky Star colored compomer, was significant irrespective of the type of the light-curing unit, and the minimum and maximum hardnesses were associated with the gold and orange colors, respectively ($p < 0.001$) (Table 1).

Table 1. Comparison of different materials with different light-curing units

Group	Light source			
	QTH	LED	p-value	Total
Berry	203.84 ± 14.591 ^{a}	211.60 ± 27.816 ^{a}	0.223	207.72 ± 22.330
Blue	241.00 ± 21.211 ^{b}	216.12 ± 25.704 ^{a}	0.001	228.56 ± 26.493
Gold	214.32 ± 22.026 ^{a}	175.116 ± 15.918 ^{b}	0.00	194.74 ± 27.440
Green	217.60 ± 15.848 ^{a}	232.88 ± 36.941 ^{a}	0.63	225.25 ± 29.171
Lemon	260.16 ± 25.998 ^{b}	323.32 ± 18.508 ^{a}	0.00	241.74 ± 29.070
Orange	265.12 ± 28.249 ^{b}	230.80 ± 15.743 ^{a}	0.00	247.96 ± 28.508
Pink	246.04 ± 18.243 ^{b}	237.04 ± 23.224 ^{c}	0.134	241.54 ± 21.162
Silver	236.84 ± 20.141 ^{b}	213.28 ± 20.501 ^{a}	0.00	225.06 ± 23.370
Z250	308.48 ± 38.500 $^{c\uparrow}$	320.56 ± 35.650 $^{d\uparrow}$	0.255	314.52 ± 37.225
Ionosit	199.60 ± 23.108 $^{a\downarrow}$	170.96 ± 10.461 $^{e\downarrow}$	0.00	189.78 ± 20.412
p-value	0.00	0.00		0.00
Total	239.3 ± 9.01147	224.072 ± 9.4747	0.00	0.00

Arrow key shows maximum and minimum surface hardness in each unit. Different letters in each column indicate statistically significant differences at $\alpha = 0.05$ by the Tukey test. The values in the table are mean ± SD.

4. Discussion

The aim of this study was to compare the surface hardness of different colors of Twinky Star compomer compared with that of Z250 composite resin and ionosit compomer, which were polymerized by two different light-curing units. The results showed a significant difference in hardness between the two light-curing units and 10 groups of materials used and the light-curing units with any of the tested materials. Since the formulation of materials in different colors of Twinky Star compomer was similar, differences in curing temperatures can be attributed to differences in the type and amount of pigments. According to the manufacturer, the composition of Twinky Star is similar to conventional compomers, and the only difference is the added pigment. The differences between the surface hardness of different colors can be attributed to the organic or inorganic pigments; there are only a few studies available in this field. The color of restorative materials is influenced by the type and content of the pigment in the material. For example, fillers, such as TiO_2, are pigments that increase the opacity of the resin. The size, type, and content of filler also are factors that affect the transmission of light and, as a result, the degree of polymerization (6). Vandenbulcke studied the curing depth of colored compomers with different light-curing units and showed that darker colors (blue and green) have greater curing depths than other colors, and curing depth was higher in the QTH than in the LED unit, which was consistent with the results of the present study about the QTH unit; in both studies the least hardness in different colors of Twinky Star compomers was associated with the gold color (although the study tools were different in the two studies, digital penetrometer versus Vickers). They attributed the difference to the wavelength distribution and glittering effects (24). Based on a study by Hwang et al. in 2007, the distribution of light transmission can be affected by glittering; glittering components include irregular shapes and sizes that can decrease the hardness of the material. Therefore, this also can reduce the hardness of the compomer (6). In addition, since different colors may have different values of the glittering components, different hardness values might be exhibited. Jafari et al. conducted a study in 2015 on the surface hardness of different colors of Twinky Star colored compomers using LED units. The results showed that the highest hardness was associated with silver, and the least hardness was associated with the blue color (7), which was not consistent with our results. They reported that the pigments in darker colors absorb more light, thereby decreasing the depth of penetration of the light into the resin; therefore, lower curing can affect the physical properties of light-cured materials and decrease microhardness. The difference between their study and our study can be explained by differences between light-curing units, the sample sizes, the different test conditions, differences in the type of Vickers devices, and differences in the amount of energy and time used to create the indentations in the Vickers devices. Diden et al. (2010) studied the degree of curing in different colors of Twinky Star compomers using LED units, and they concluded that, in 40 seconds, blue and pink exhibited a higher degree of conversion than gold, green, lemon, orange, and silver. This difference in the degrees of conversion and hardness can be explained by differences in size, type, and amount of glittering components (25). The results of their study were partly consistent with those of the present study; in the present study, too, with the use of an LED unit, the pink color exhibited the highest hardness, and gold exhibited the least hardness. A study by Hwang et al. (2007) evaluated the surface hardness of different colors of Twinky Star colored compomer and its optical characteristics and showed that blue and silver had high light transmission and hardness, and gold, pink, and lemon colors exhibited less light transmission. Higher light transmission means greater light penetration into the depth of samples without being absorbed on the track. The transmission of light in gold color was the least that seems to have a higher light absorption, consistent with our results (7). In fact, gold color had the least hardness among the different colors of Twinky Star compomer based on our study; in our study and in studies by Hwang and Vandenbuke and Diden similar results were achieved. However, in relation to the highest hardness in different colors of Twinky Star compomer, there was no consensus between the studies. Uhl et al. reported significant differences in the degree of curing with the use of different materials and different light-curing units, indicating the effect of the wavelength of light-curing units on the photoinitiator. In fact, not only are there differences in curing behavior between different materials, but there also are differences in one single material. This, in fact, is the role of pigments and their effects on the depth of curing (26). In the present study, the QTH light-curing unit generally produced higher hardness than the LED light-curing unit. However, in the Z250 composite resin and berry and green compomers, the results were the opposite, with LED producing the higher hardnesses. In studies by Safarcherati et al. (2009) (27) and Esmaili et al. (2012) (28) on the hardness of composite resins with the use of LED and QTH light-curing units, there was no significant difference between the two units in hardness, consistent with the results of the present study. Probably due to the similarity of wavelengths of the LED camphorquinone optical absorption spectrum initiators, LED can provide higher hardness than QTH because camphorquinone is the most common photoinitiator in composite resins, with an absorption spectrum of about 468 nm. However, since the wavelength of LED units is usually narrow and the wavelength of QTH units includes a broader range of light, it is possible that some compomers do not have maximum absorption in the LED wavelength, resulting in lower hardness; but since its absorption wavelength is in the QTH spectrum, it results in higher hardness (29). Polydorou et al. (2008) reported that a QTH unit resulted in higher hardness than an LED unit in composite resins. In relation to compomers, it is consistent with our results; they attributed this to substantial heating of the light-curing units, which results in hardening of the surface of the composite sample (30). In this study, Z250 composite resin was used, which exhibited the highest hardness based on a study by Alaghemand et al. (2013) on the surface hardness of different of types of composite resins (31). In the present study, the highest hardness was associated with the Z250 composite resin, which was similar to a study by Price et al. (2009) on the hardness of five composite resins with the use of LED and QTH light-curing units (32). Certainly, the hardness of composite materials depends on their composition, too, and since Z250 is a microhybrid composite resin and has a high percentage of filler and camphorquinone photoinitiator, it seems that these components may be responsible for its higher hardness (33, 34). A study by Koupis et al. (2006) on the curing degree of composite resins and compomers showed that compomers have less hardness than Z250 composite resin, consistent with the present study. They suggested that the higher hardness of the hybrid composite resin material can be attributed to the type of the material. Z250 composite resin has higher light transmission index and, as a result, a higher curing degree. Compomers include some additional specific monomers and glass components, such as barium aluminofluorosilicate; it appears that these changes can affect the curing of compomers to a greater extent than the conventional composite resins (35). A study by Khodadadi et al. on the surface hardness of silver-colored Twinky Star compomers, with a hybrid composite resin with two QTH and LED units, showed that, in compomers, the QTH unit resulted in higher surface hardness than the LED unit, and surface hardness of composite resin was higher than compomer, consistent with the present study (36).

5. Conclusions

The results showed different surface hardness in different colors of compomer. Compomer color and the light-curing unit used affected its microhardness. Although colored compomers are useful for the restoration of teeth in children, it seems that additional research is necessary due to the lack of laboratory and clinical studies.

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Conflict of Interest:

There is no conflict of interest to be declared.

Authors' contributions:

All authors contributed to this project and article equally. All authors read and approved the final manuscript.

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