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Research Article

The color stability of different composite shades using variable light-curing times

Hozan Tofiq Ahmed *, Anas Hussein Yousif , Abdulkareem Ramadhan Ibrah Doaa Waleed Jameel

Conservative Department, College of Dentistry, University of Duhok, Kurdistan Region, Iraq
* Corresponding author: Hozan.ahmed@uod.ac

Abstract: The current study aimed to evaluate how the color stability of the composite resins was affected by the duration of light-curing time using light-emitting diode (LED) curing units and various composite shades. **Materials and methods**: The LED curing unit was used in different durations (10s), (20s), and (40s) for each shade (A1, A2) to prepare and polymerize samples in two shades of two different types of composite resin. The initial color parameters (L*, a*, b*, and E*) were determined using a spectrophotometer. After that, every sample was exposed to a thermocycling regimen that included 500 cycles in water at 55°C and 5°C. The final color readout was then obtained, and the Tukey-Kramer post-hoc test and ANOVA were used to ascertain the color changes. **Results**: Following the thermocycling regimen, the specimens' mean delta E* ranged from 0.055 to 4.151. The specimens' mean delta a*, delta L*, and delta b* were primarily negative. Most of the specimens showed noticeable color changes, shifting toward green discoloration (negative delta a*), blueish discoloration (negative delta b*), and a generally darker value (negative delta L*). **Conclusion**: Since the effect was more likely to depend on the composition of the constituent materials than on the actual shade categorization, the color change that the specimens experienced could not be predicted in connection to curing duration and types of composite shades. The degree of color change in composite resins was not significantly impacted by the time of the light cure or the variation in hues.

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Keywords: Composite resin; Color stability; Composite shades; light curing time; light-emitting diodes

INTRODUCTION

Nowadays, the need to treat dental defects in a way that achieves exceptional, appropriate, and aesthetically pleasing results has improved due to patient and dentist aesthetic outlooks. The composite resins are esthetic restorative materials in most clinical use that are made to meet these outlooks. [1]

Even though composite resins' mechanical, physical, and aesthetic qualities have significantly improved, one of the main reasons for clinical failure is still the issue of discoloration. The development of new restorative materials is a result of the search for the perfect restorative material with superior mechanical and aesthetic qualities. Many of the composite resins are accessible for aesthetic restorations that vary from each other according to the type, size, and quantity of filler particles and the type of resin matrix. [2]

The dental light-curing unit (LCU) is a fundamental prerequisite for consistent long-term clinical success and is necessary for composite restorations to achieve the manufacturer's intended properties. [3] However, time constraints in a busy clinic often led clinicians to shortcut the length of their light curing. This could lead to the insufficient photopolymerization of the composite resin. Inadequate curing of composite resin will lead to many issues, for example, mass fracture, marginal leakage, and sensitivity after tooth filling as a result of inadequate qualities and poor clinical outcomes. [4]

The ability to choose the appropriate color shade of composite material is essential to creating dental fillings that are as undetectable as probable compared to the accepted dentition as dental aesthetics become increasingly important. Due to the sensitivity of the human eye to color shifts, especially in lighter shades, it is essential to be able to predict the ultimate color attributes of the composite resin utilized for tooth restoration. [5]

Important elements that impact the color stability of the composite resin include the photoinitiator system, resin matrix, and light curing variables such exposure duration and light power. [6]

The composite's yellow photoinitiator component is known as camphorquinone (CQ). Even though it is used in limited amounts, it has a considerable impact on the ultimate color of the material because residual CQ can change the color of the material as it is not transformed during light curing. Additionally, the other essential components of the photo initiator system include tertiary amines, which can generate byproducts during photoreaction that tend to induce yellow to red-brown color when exposed to light or heat. [7]

The color stability of composite resin can also be impacted by inadequate curing of the material and the kind of light curing units used. [2] The purpose of this study was to evaluate how the color stability of the composite resins was affected by the duration of light-curing time using light-emitting diode (LED) curing units and various composite shades

MATERIALS AND METHODS

There are two types of composite resin., Tokuyama (PALFIQUE LX5) and G-aenial (GC) were selected in shades of A1 and A2. The light-curing device that was utilized was light-emitting diodes (O-star Wide-Spectrum, Guilin woodpecker medical instrument Co., Ltd) Figure 1 and the curing time that selected was 10s, 20s and 40s. Twelve groups of 10 specimens each) A1=30 samples, A2=30 samples) for each type of composite resin) A total of 120 specimens were prepared. [8]

Figure (1): Light-curing unit light emitting diode (O-star Wide-Spectrum)

According to the group, samples with a diameter of 5 mm and a thickness of 2 mm were made by using a custom-made ring. A glass slide was used to compress the composites once they were positioned into the matrix. The composites were then placed into the matrix, and any extra material was squeezed out using a glass slide. The LED light curing equipment was then used to light activate the samples at a distance of 1mm. Next, the samples were removed from the matrix, then by using the medium and fine aluminium oxide-impregnated discs (Sof-Lex, 3M ESPE, St. Paul, MN, USA), respectively, all the samples were polished for 10s. The caliper was used to measure the thickness because changes in the test specimen's thickness could affect the results. [9]

Color measurement

The spectrophotometer device was calibrated in accordance with the manufacturer's instructions before each specimen's experimental measurements. After

being inserted into the charging station, the Vita Easyshade Advance (VITA Zahnfabrik H. Rauter GmbH & Co. KG) Figure 2 recognized the calibration block. Calibration was finished after two brief signal tones. The same researcher made all of the measurements at the center of each specimen. [9]

Figure (2): Vita Easyshade Advance

The specimen was set up on a white tile, and the first color readout was obtained using a spectrophotometer (VITA Easyshade Advanced). The samples were then put through an AMMP entre thermocycling program (ATDM T6-ED Zactron Sdn. Bhd.) that included 500 cycles with dwell times of 60 seconds each, alternating between water baths that were 55°C and 5°C. Figure 3. [8]

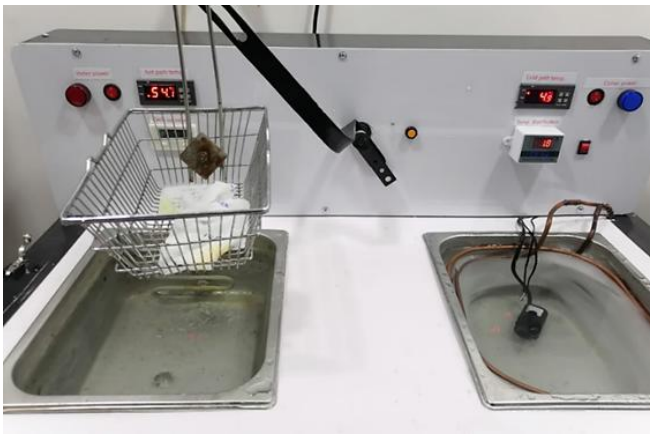

Figure (3): thermocycling

Using the following formula, color stability (ΔE) was calculated by comparing the coordinates obtained before and after the samples' aging process using the thermocycling regimen.

$\Delta E = [(\Delta L)2 + (\Delta a)2 + (\Delta b)2\ ]1/2$

The color change is represented by ΔE, ΔL = LF - LI, Δa = aF - aI, and Δb = bF - bI. The final readout, which comes following regimen, is denoted by the subscript letter "F," while the initial readout is denoted by "I." ΔL denotes the luminosity difference, Δb the yellow-blue parameter difference (-b* = blue and +b* = yellow), and ΔL the red-

green parameter difference (-a* = green and +a* = red). Values of ΔE that were 3.3 or above were deemed clinically inappropriate. [10]

RESULTS

Tables 1. &2 show the means values and standard deviation of GC and tukoyama composite resin after the thermocycling regimen, the specimens' color stability (ΔE) and all color parameters (ΔL, Δa, and Δb) are displayed.

According to the Table2.found that the Tukoyama composite with curing times of 10 and 20 seconds for shade A1 had ΔE ≥ 3.3, which is deemed clinically undesirable; other shades for each composite had Δclinically acceptable E values. However, all other groups did not, show any statistically significant differences according to the Tukey Kramer post hoc test or ANOVA (p>0.05).

Table (1): GC composite resin's overall averages and standard deviations for ΔL, Δa, Δb, and ΔE

Composite shade		**GC A1**			**A2**		
Time		**10s**	**20s**	**40s**	**10s**	**20s**	**40s**
ΔL	mean	-0.307	-0.459	-0.188	-0.038	-0.11	-0.135
	SD	0.133	0.280	0.158	0.064	0.074	0.106
Δa	mean	-1.38	-2.276	-0.835	-0.176	-0.488	-0.496
	SD	0.602	0.879	0.694	0.288	0.337	0.510
Δb	mean	-0.484	-0.807	-0.294	-0.066	-0.17	-0.155
	SD	0.209	0.308	0.246	0.113	0.118	0.294
ΔE	mean	0.055	0.199	0.305	0.055	0.199	0.305
	SD	0.062	0.228	0.310	0.062	0.228	0.310

Table (2): Tokuyama composite resin's overall averages and standard deviations for ΔL, Δa, Δb, and ΔE

Composite shade		**Tukoyama A1**			**A2**		
Time		**10s**	**20s**	**40s**	**10s**	**20s**	**40s**
ΔL	mean	-0.541	-0.492	-0.073	-0.019	-0.106	0.069
	SD	0.222	0.074	0.087	0.095	0.089	0.137
Δa	mean	-2.502	-2.206	-0.328	-0.39	-0.466	0.307
	SD	0.979	0.338	0.391	0.95	0.409	0.617
Δb	mean	-0.856	-1.074	-0.097	-0.03	-0.164	0.112
	SD	0.347	0.918	0.161	0.148	0.145	0.216
ΔE	mean	4.151	3.564	0.145	0.497	0.216	0.256
	SD	4.076	1.979	0.120	1.245	0.192	0.301

DISCUSSION

Depending on the polymerization process, color changes may result in modifications to the optical characteristics of the resin. [11]

The degree of conversion is determined by variables like the curing time and the polymerization unit's radiant intensity. [12]

Color changes and increased water sorption of the resin matrix could result from the remaining unchanged methacrylate groups. [13] Better color stability after 40 seconds could be the result of a faster rate of polymerization during a longer curing period. Longer curing times cause more photons to reach the composite resin, which in turn excites more camphorquinone molecules. This leads to the production of more free radicals, which further accelerates the polymerization of the composite resin. [14]

In the current study, the thermocycling regimen after different time of curing was used to determine the effect of light cure duration on color stability of different type of composite resins in virous shades and the results obtained, that the curing time for various shades of composite resin had no noticeable impact on the color stability of the resin, could not be ignored. Despite the various curing times, no noticeable variations in color stability were observed for the various hues of composite resin. Despite the

various curing times, no appreciable variations in color stability were observed for the various hues of composite resin.

However, the Tukoyama composite shade A1 with a curing time of 10s had the largest overall alterations of color stability ΔE of 4.151, although the results varied depending on the curing periods and colors of the composites. No specific shade or cure period showed noticeable variations in color stability.

Except for tukoyama composite shade A2 that was cured for 40s were shows the color parameter Δa positive mean value, and the color parameter Δa displayed a negative mean value e for all other sample groups, indicating that the specimen had transitioned to green discolouration. The accelerator or their by-product created during the initiation phase that was thermally attacked by the thermocycling regimen was responsible for this. [15] Except for Tukoyama composite shade A2, which was cured for 40 seconds, all shades and curing times exhibit bluish discoloration, as shown by the color parameter Δb yielding a negative value. If accelerators overlap and overcompensate the blue color shift with their byproducts, a yellow color change may be observed.

Furthermore, every curing time applied to various composite resin shades resulted in a negative value (shifted darker) for the color parameter ΔL in every sample except Tukoyama composite shade A2, which was cured for 40 seconds. Unknown factors contributed to the variations in these particular hues and curing times.

A transition to a higher refractive index would be suggested by an increase in lightness caused by increasing opacity, which would also indicate an increase in water sorption. [7]

The result of the study disagrees with the study of Teimourian (2019) [16] in which found that when the irradiation period is increased, there is a noticeable color shift. ($P < 0.05$).

However, Bejeh et al. (2012) [17] evaluated the impact of curing time on composite resin color change and showed that a longer curing time (20 seconds) resulted in a noticeably larger color shift than a shorter curing time (10 seconds).

According to the Brackett et al. (2007) [18] the authors discovered that when using Quartz tungsten halogen (QTH) light, all hybrid product shades show noticeable yellowing, but only when using one microhybrid and one microfill.

In the study of Sadek et al. (2018) [8] there was only one composite category evaluated, and that was the nanohybrid universal composite resin in various shades. It was possible to analyze the optical behavior of the composite over time by evaluating not only the final L*, a*, and b* value as conducted by Bracket et al. (2007)[18] but also the fluctuation in color parameters (ΔL, Δa, and Δb).

CONCLUSIONS

The study's findings indicate that not all materials met clinically acceptable standards; some even had color change levels that were inappropriate, with ΔE >3.3. A comparison of the curing time for different colors of composite resin revealed no visible changes in color stability; this appears to depend more on the composition of the product than on the shade classification.

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Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript

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استقرار لون الظلال المركبة المختلفة باستخدام أوقات معالجة ضوئية متغيرة

هوزان أحمد, أنس يوسف, عبدالكريم ابراهيم , دعاء جميل

الملخص

الأهداف: الهدف من هذه الدراسة هو تقييم تأثير مدة التصلب باستخدام وحدات الأشعة فوق البنفسجية (LED)وألوان المركب المختلفة على اســتقرار لون الراتنجات المركبة. **المواد وطرائق العمل**: تم تحضــير العينات بلونين من نوعين من الراتنج المركب، وتم تلبيدها باستخدام وحدة التصلب بالأشعة فوق البنفسجية. باستخدام جهاز الطيف الضوئي، تم قياس المعلمات الأولية للون(L* ،a* b*)E*, ثم تم تعريض جميع العينات إلى نظام تســخين وتبريد يتضــمن)500 (دورة في الماء بدرجات حرارة 55 درجة مئوية و 5 درجات مئوية. بعد ذلك تم قياس اللون النهائي لتحديد التغيرات اللونية باستخدام اختبار ANOVA واختبار Tukey-Kramer بعد الفحص. **النتائج**: بعد تطبيق نظام التســخين والتبريد، تراوحت قيم دلتا E* للعينات بين 0.055 و 4.151. وكانت قيم دلتا a* و دلتا L* و دلتا b*للعينات في الغالب سـلبية. تم ملاحظة تغير لون ملحوظ في معظم العينات، حيث كانت أكثر قتامة (دلتا L* سـلبية)، مع تحول نحو تغير اللون الأخضــر (دلتا a* سـلبية) وتغير اللون الأزرق (دلتا b* سـلبية. **الاســتنتاجات**: لم يكن من الممكن التنبؤ بتغير اللون الذي تعرضــت له العينات بناءً على مدة التصــلب وأنواع ألوان الراتنج، حيث كان التأثير يعتمد على تكوين المواد الفردية بدلاً من تصــنيف اللون الفعلي. لم يكن لمدة التصلب بالأشعة فوق البنفسجية أو اختلاف الألوان تأثير كبير على مقدار تغير اللون في الراتنجات المركبة