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# Should My New Curing Light Be An LED?

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### Clinical Relevance

This study provides information concerning curing light unit purchase decision criteria and supporting evidence to compare various curing light units that are on the market.


## SUMMARY

**The new generation LED curing light units have significantly improved curing performance compared to first generation lights, and even some second generation LED curing light units. This study compared the curing performance of 10 new generation LED light curing units (FLASH-lite 1401, LE Demetron 1, Coltolux, Ultra-Lume 5, Mini LED, bluephase, Elipar FreeLight 2, Radii, Smartlite IQ and Allegro) for depth of cure against a high-powered halogen curing light unit (Optilux 501). Depth of cure measurements were utilized per the ANSI/ADA No 27 standard to detect differences between the lights at three time intervals (10, 20 and 40 seconds). A total of 660 samples were prepared (n=10/group). A full factorial ANOVA and Tukey's HSD test showed FLASH-lite 1401 performed significantly better than the other lights at 10- and 20-second time intervals (*p*<0.01). This study also demonstrated that an exposure time of 20 seconds or longer assures a better depth of cure, 40 seconds being the optimal polymerization time for all of the curing light units.**


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## INTRODUCTION

A major factor in the success and predictability of resin composite restorations is the degree of resin polymerization achieved during restoration placement. The polymerization of resin composites depends on many intrinsic conditions, such as the type of the photo initiator, composition of the filler particles, shade and degree of translucency of the material. Additionally, the combination of the curing light unit's effective spectral output, wavelength and exposure duration is required for adequate polymerization.[1-2] The physical properties of restorations will be compromised if all of these parameters are not met, and early failure may be expected. Therefore, it is important to have dental curing light units that can provide continuous and adequate spectral output.

In addition to light output, the ergonomic features of curing light units have also become important. Some of the new light designs are aimed at increasing safety and efficacy of the curing light units and providing ergonomic advantages for clinicians. Specific factors contribute to the desired functional and ergonomic features of curing lights and should be considered prior to their purchase. These factors include the type of light source, power density, heat generation and other ergonomic factors, such as the presence of cords, built-in radiometers, cooling fans and the size and shape of the curing light units.

Currently, the most commonly used light source for polymerization is conventional quartz tungsten halogen (QTH).[3] This technology, introduced in the late 1970s, was an improvement over ultraviolet lights and has since been the polymerization source of choice. Although these lights are manufactured with relatively low-cost technology, the shorter life of the QTH light bulb and the gradual degradation of the filter compromises consistent light output.

The next generation of lights to be developed were the plasma-arc (PAC) and argon laser units, which were designed to increase the effectiveness of the constant high light output and decrease the time required to polymerize resin composites. Laser units require a larger capacity for power supplies and cooling, making them complex and expensive, besides stipulating user precautions.

The newest light technology is the light emitting diode (LED). The peak wavelength of LEDs is in a range of 455-480 nm, the ideal range for activating the most popular photo initiator, camphorquinone (CQ), which has a peak wavelength of 468 nm. LED curing light units were designed with major advantages over existing light units, such as being lightweight, cordless, portable, having a longer life span, no requirement for filter systems and less heat generation.[4]

All curing lights produce heat at varying levels. Some high-intensity units produce less heat than lower output units. In general, long wavelength light curing units generate more heat per unit area.[5-7] Resin composites generate some heat while they polymerize.[5] However, the remaining dentin thickness of the preparation plays a significant role in preventing heat diffusion.[8-9] Even though PAC lights polymerize resin composites faster than other lights, they cause a higher risk of pulpal damage due to their increased heat generation compared to QTH and LED curing light units.[10-11] Heat generation also can cause degradation of the light bulbs, and therefore diminish the light output.

In order to compare the power of curing light units, the meaning of power density should be understood. Power density is associated with the amount of light output that the curing light unit can provide per unit area, which therefore assists in effective polymerization of restorations. Power density varies from 400 $mW/cm^2$ to 1,600 $mW/cm^2$, depending on the curing light unit. Factors that can effect the power density of units include increased distance of the light tip from the substrate, aged/damaged curing lamps, filters and tips, and other inhibiting factors, such as the presence of another material between the light and the substrate—examples being protective shields and all-ceramic restorations.

Studies have reported that first-generation LED curing light units did not provide sufficient light output.[12-14] Since that time, the search for more effective LEDs has produced the second-generation LED curing lights that provide higher light output.[15] Unlike first generation LEDs, heat generation can be an issue, and cooling fans, along with heat-sink features, were incorporated into the units to increase the life of the LEDs.[16] Even though second-generation LED units provided advantages over QTH lights, inconveniences, such as degradation of the light output, cooling fans or automatic shut-off due to over-heating remained a challenge for manufacturers. To offset these concerns, new research and development efforts have focused on smaller cordless units with a constant high light output without causing any compromise related to over-heating. The anticipated result is a reliable, simple and long-lasting curing light unit that eliminates technical variability during the polymerization of resin composite restorations.

Significant improvements have been made in a short amount of time in the newer LED dental curing units' technology. Ten LED curing light units were evaluated, along with a traditional high-powered QTH light curing unit, to measure the effectiveness on depth of cure and maintenance of light output overtime. This study tested the hypothesis that the high-powered LED curing light units provide equal or better depth of cure and maintenance of light output compared to high-powered QTH light curing units.

## METHODS AND MATERIALS

The curing light units tested for this study were: FLASH-lite 1401, LE Demetron 1 with 11 mm curing probe (Battery S/N: 921552), Coltolux LED, UltraLume LED 5, Mini LED, bluephase LED, Elipar FreeLight 2, Radii, Smartlite IQ and Allegro compared to Optilux 501 with turbo tip and boost mode for depth of cure and maintenance of light output overtime (Table 1). Figures 1 and 2 display the curing light units tested in this study.

Table 1: *Curing Light Units and Their Manufacturers*

| Curing Light Units | Manufacturer | Serial # | Light Source | Corded/Cordless |
|---|---|---|---|---|
| FLASH-lite 1401 | Discus Dental, Inc Culver City, CA, USA | 0524059 | LED | cordless |
| LE Demetron I | Kerr Demetron Orange, CA, USA | 771030035 | LED | cordless |
| Allegro | Den-Mat Santa Maria, CA, USA | F044010022 | LED | cordless |
| bluephase | Ivoclar Vivadent Amhest, NY, USA | 1548165 | LED | corded/cordless |
| Mini LED | Acteon Group Bordeaux, France | 196-10470 | LED | cordless |
| Ultra-Lume 5 | Ultradent South Jordan, UT, USA | 508822 | LED | corded |
| Smartlite IQ | Dentsply Caulk Milford, DE, USA | 040712 | LED | cordless |
| Coltolux LED | Coltene Whaledent Alstatten, Switzerland | 04112269 | LED | cordless |
| Elipar FreeLight 2 | 3M/ESPE St Paul, MN, USA | 939826006824 | LED | cordless |
| Radii | SDI Victoria, Australia | 1-3362 | LED | cordless |
| Optilux 501 | Kerr Demetron Orange, CA, USA | 5810891 | QTH | corded |

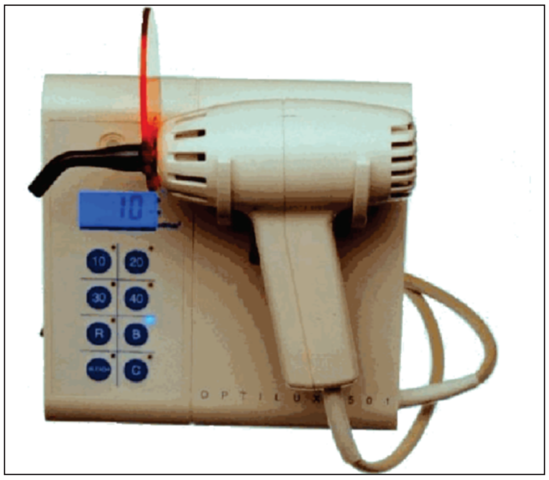


Figure 1. *QTH curing light unit used in the study.*

The depth of cure of composite samples was tested using the "scrape test method," as suggested by ANSI/ADA No 27.[17] The depth of cure was tested on A2 anterior and A3 posterior shades of Matrixx hybrid resin composite (Discus Dental, Inc, Culver City, CA, USA), with three time intervals (10 seconds, 20 seconds and 40 seconds) (Table 2).

Ten resin composite samples were prepared by the same operator for each test group using a Teflon split mold (4 mm in diameter, 6 mm long). The mold was placed on a mylar strip that was positioned on white filter paper. The mold was slightly overfilled with Matrixx resin composite. Another mylar strip was placed on top, and a glass slide was pressed to remove the excess material. The composite was light cured, considering group combination with curing time and composite shade (Table 2). The light tip was directly placed on the mylar strip.

It is possible for the light output to degrade due to overheating of the light bulb. As a result of this degradation, all the samples from a particular light group could not be polymerized equally if the light-curing unit would have been utilized continuously. In order to prevent a possible side effect of light output degradation, only one sample from each light group was cured at a time, and each one of the lights was used in order. In this way, a light that was just used could cool down and recharge, while the other lights were being used. It was assumed that light output would remain at equal levels by having the lights cool down between polymerization sessions.

Table 2: *Each Curing Light Unit Was Tested in Three Time Intervals for Each Composite Shade*

| Polymerization Time (seconds) | 10 | | 20 | | 40 | |
|---|---|---|---|---|---|---|
| Composite Shade (Matrixx) | A2 | A3 | A2 | A3 | A2 | A3 |
| Expiration Date | A2: 06/2007 | | | A3: 05/2007 | | |
| Lot # | A2: 0426008 | | | A3: 04198023 | | |

Specimens were removed from the mold, and the soft, unpolymerized material from the bottom of the sample was removed with a plastic instrument. The height of


Figure 2. *LED curing light units used in the study.*

Table 3: *Depth of Cure Means and Standard Deviations by Time*

| Time (seconds) | Mean (mm) | Std Dev |
|---|---|---|
| 10 | 1.73—**A** | 0.19 |
| 20 | 2.16—**B** | 0.23 |
| 40 | 2.93—**C** | 0.08 |

*Means NOT connected by the same letter are significantly different p<0.01.*

Table 4: *Depth of Cure Means and Standard Deviations for Time by Matrixx Composite*

| | Matrix | | | |
|---|---|---|---|---|
| | Matrixx A2 | | Matrixx A3 | |
| Time (seconds) | Mean (mm) | Std Dev | Mean (mm) | Std Dev |
| 10 | 1.68–**E** | 0.19 | 1.79–**D** | 0.16 |
| 20 | 2.29–**C** | 0.17 | 2.04–**B** | 0.22 |
| 40 | 2.93–**A** | 0.07 | 2.93–**A** | 0.09 |

*Means NOT connected by the same letter are significantly different p<0.01.*

Table 5: *Matrix A2 Depth of Cure (mm) Mean and Standard Deviations*

| | Time (seconds) | | | | | |
|---|---|---|---|---|---|---|
| | 10 | | 20 | | 40 | |
| Curing Light Unit | Mean | Std Dev | Mean | Std Dev | Mean | Std Dev |
| Allegro | 1.69 | 0.11 | 2.06 | 0.15 | 2.90 | 0.05 |
| bluephase | 1.86 | 0.09 | 2.26 | 0.19 | 2.92 | 0.03 |
| Coltolux LED | 1.67 | 0.12 | 2.39 | 0.11 | 2.87 | 0.13 |
| Smartlite IQ | 1.55 | 0.14 | 2.39 | 0.09 | 2.95 | 0.03 |
| Elipar FreeLight 2 | 1.84 | 0.12 | 2.39 | 0.06 | 2.96 | 0.01 |
| FLASH-lite 1401 | 1.95 | 0.08 | 2.49 | 0.11 | 3.01 | 0.03 |
| LE Demetron-1 | 1.47 | 0.18 | 2.22 | 0.12 | 2.91 | 0.05 |
| Mini LED | 1.64 | 0.09 | 2.14 | 0.11 | 2.93 | 0.05 |
| Radii | 1.51 | 0.11 | 2.25 | 0.14 | 2.93 | 0.04 |
| Ultra-Lume 5 | 1.66 | 0.18 | 2.28 | 0.13 | 2.89 | 0.05 |
| Optilux 501 | 1.42 | 0.14 | 2.35 | 0.15 | 3.01 | 0.01 |

the remaining sample was measured with a digital caliper (Traceable Digital Caliper, S/N: Y118879) from three points, and the average of the three points was recorded. To determine the depth of cure, the average number was divided by two.[1,17]

Based on the results of the initial phase of this study, the highest performing LED curing light unit, FLASH-lite 1401, and a secondary LED curing light unit that was manufactured by the same company as the QTH unit (LE Demetron 1) were utilized to determine the effectiveness of the light output over time against Optilux 501. This selection allowed for keeping with the same manufacturer, while using two categories of light systems. After fully charging the lights, each light was activated for 40-second intervals for 40 cycles, and the light outputs were measured with a hand-held radiometer (Model 100 Curing Radiometer, Demetron Research Corp, Danbury, CT, USA, SN: 109896) after each cycle. No cool-down time was provided between the cycles.

Full factorial ANOVA was utilized to determine main effects

| Table 6: *Matrix A3 Depth of Cure (mm) Mean and Standard Deviations* | | | | | | |
|---|---|---|---|---|---|---|
| | **Time (seconds)** | | | | | |
| | 10 | | 20 | | 40 | |
| **Curing Light Unit** | **Mean** | **Std Dev** | **Mean** | **Std Dev** | **Mean** | **Std Dev** |
| Allegro | 1.59 | 0.11 | 1.92 | 0.11 | 2.84 | 0.11 |
| bluephase | 1.81 | 0.08 | 2.06 | 0.07 | 2.91 | 0.04 |
| Coltolux LED | 1.72 | 0.08 | 2.08 | 0.07 | 2.90 | 0.08 |
| Smartlite IQ | 1.76 | 0.10 | 1.89 | 0.08 | 2.91 | 0.07 |
| Elipar FreeLight 2 | 1.88 | 0.07 | 1.95 | 0.11 | 2.94 | 0.07 |
| FLASH-lite 1401 | 1.98 | 0.12 | 2.47 | 0.15 | 3.01 | 0.07 |
| LE Demetron-1 | 1.96 | 0.03 | 2.07 | 0.07 | 2.93 | 0.07 |
| Mini LED | 1.67 | 0.12 | 1.77 | 0.16 | 2.89 | 0.15 |
| Radii | 1.92 | 0.05 | 2.17 | 0.17 | 2.98 | 0.05 |
| Ultra-Lume 5 | 1.59 | 0.06 | 1.97 | 0.15 | 2.99 | 0.08 |
| Optilux 501 | 1.37 | 0.09 | 2.19 | 0.14 | 3.01 | 0.01 |

Table 7: *Tukey HSD Least Square Means Differences (10 second polymerization interval)*

| **Level** | | | | | **Least Sq Mean** |
|---|---|---|---|---|---|
| FLASH-lite 1401 | A | | | | 1.9667088 |
| Elipar FreeLight 2 | | B | | | 1.8579209 |
| bluephase | | B | | | 1.8346128 |
| LE Demetron | | | C | | 1.7165320 |
| Radii | | | C | | 1.7152609 |
| Coltolux LED | | | C | | 1.6952441 |
| Smartlite IQ | | | C | | 1.6551263 |
| Mini LED | | | C | | 1.6549242 |
| Allegro | | | C | | 1.6397811 |
| Ultra-Lume 5 | | | C | | 1.6222306 |
| Optilux 501 | | | | D | 1.3962500 |

*Levels not connected by same letter are significantly different.*

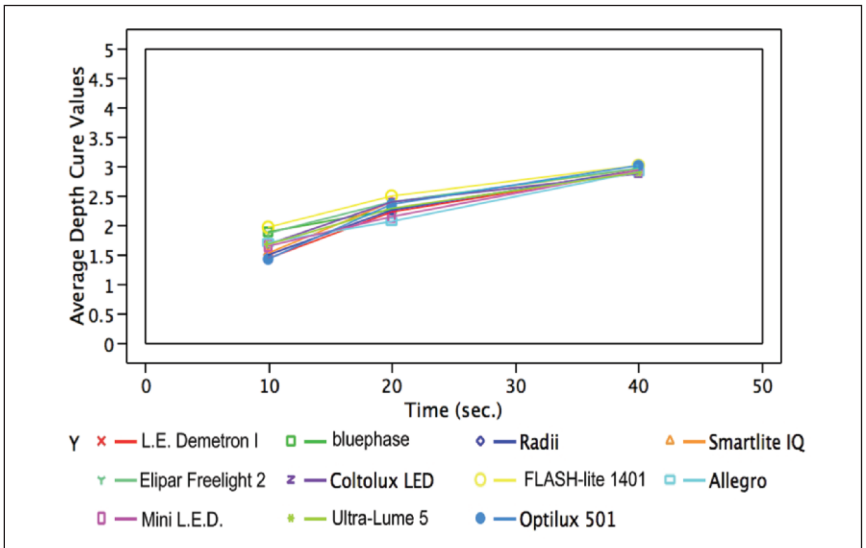


Figure 3. *Comparison between the lights in relationship to exposure time and depth of cure (mm) for Matrixx A2 anterior.*

(time, light, composite), as well as interactive effects (time as a function of light [time*light]) of the variables. Tukey's HSD test was used to determine individual differences.

## RESULTS

The average depth of cure per time period is displayed in Table 3. There was a significant difference among the three time levels ($p<0.01$). The average depth of cure for time by composite shade is displayed in Table 4. The results indicate that variables Matrixx A2 and A3 at 10 and 20 seconds are significantly different ($p<0.01$).

The average depth of cure for curing light unit by time and by composite shade is displayed in Tables 5 and 6.

The instrument level analysis indicates that the overall highest depth of cure in the 10-second polymerization time was achieved by FLASH-lite 1401 (1.97 mm), which was statistically significant compared to the rest of the curing lights tested, while Optilux 501 produced the lowest depth of cure at the 10-second level (1.40 mm) ($p<0.01$) (Table 7). Table 8 displays the differences between lights combined with time and composite shades. Results from the 40-second polymerization time were not included in Table 8 to prevent overcrowding the table. There was no statistically significant difference between the majority of the light curing units in the 40-second level. The exceptions were Optilux 501 and FLASH-lite 1401 being statistically significantly better than Coltolux and Allegro ($p<0.01$). Figures 3

Table 8: *Tukey HSD Least Square Means Differences–40-second level is not included in the table. Levels not connected by same letter are significantly different.*

| Time, Curing Light, Composite Shade | | | | | | | | | | | | | | | | | | | | | | Least Sq Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20, FLASH-lite 1401, Matrixx A2 | A | | | | | | | | | | | | | | | | | | | | | 2.4941667 |
| 20, FLASH-lite 1401, Matrixx A3 | A | | | | | | | | | | | | | | | | | | | | | 2.4738333 |
| 20, Elipar FreeLight 2, Matrixx A2 | A | B | | | | | | | | | | | | | | | | | | | | 2.3921667 |
| 20, Coltolux LED, Matrixx A2 | A | B | | | | | | | | | | | | | | | | | | | | 2.3915000 |
| 20, Smartlite IQ, Matrixx A2 | A | B | | | | | | | | | | | | | | | | | | | | 2.3876667 |
| 20, Optilux 501, Matrixx A2 | A | B | | | | | | | | | | | | | | | | | | | | 2.3491327 |
| 20, Ultra-Lume 5, Matrixx A2 | | B | C | | | | | | | | | | | | | | | | | | | 2.2758333 |
| 20, bluephase, Matrixx A2 | | B | C | D | | | | | | | | | | | | | | | | | | 2.2620000 |
| 20, Radii, Matrixx A2 | | B | C | D | | | | | | | | | | | | | | | | | | 2.2548333 |
| 20, LE Demetron, Matrixx A2 | | B | C | D | E | | | | | | | | | | | | | | | | | 2.2228333 |
| 20, Optilux 501, Matrixx A3 | | | C | D | E | | | | | | | | | | | | | | | | | 2.1906670 |
| 20, Radii, Matrixx A3 | | | C | D | E | F | | | | | | | | | | | | | | | | 2.1688333 |
| 20, Mini LED, Matrixx A2 | | | C | D | E | F | G | | | | | | | | | | | | | | | 2.1383333 |
| 20, Coltolux LED, Matrixx A3 | | | | D | E | F | G | H | | | | | | | | | | | | | | 2.0821667 |
| 20, LE Demetron, Matrixx A3 | | | | D | E | F | G | H | | | | | | | | | | | | | | 2.0748333 |
| 20, Allegro, Matrixx A2 | | | | | E | F | G | H | I | | | | | | | | | | | | | 2.0581667 |
| 20, bluephase, Matrixx A3 | | | | | E | F | G | H | I | | | | | | | | | | | | | 2.0570000 |
| 10, FLASH-lite 1401, Matrixx A3 | | | | | | F | G | H | I | J | | | | | | | | | | | | 1.9829630 |
| 20, Ultra-Lume 5, Matrixx A3 | | | | | | | G | H | I | J | | | | | | | | | | | | 1.9740000 |
| 10, LE Demetron, Matrixx A3 | | | | | | | G | H | I | J | K | | | | | | | | | | | 1.9618519 |
| 10, FLASH-lite 1401, Matrixx A2 | | | | | | | G | H | I | J | K | | | | | | | | | | | 1.9504545 |
| 20, Elipar FreeLight 2, Matrixx A3 | | | | | | | G | H | I | J | K | | | | | | | | | | | 1.9478333 |
| 20, Allegro, Matrixx A3 | | | | | | | | H | I | J | K | | | | | | | | | | | 1.9188333 |
| 10, Radii, Matrixx A3 | | | | | | | | H | I | J | K | L | | | | | | | | | | 1.9170370 |
| 20, Smartlite IQ, Matrixx A3 | | | | | | | | H | I | J | K | L | | | | | | | | | | 1.8936667 |
| 10, Elipar FreeLight 2, Matrixx A3 | | | | | | | | | I | J | K | L | M | | | | | | | | | 1.8762963 |
| 10, bluephase, Matrixx A2 | | | | | | | | | | J | K | L | M | N | | | | | | | | 1.8601515 |
| 10, Elipar FreeLight 2, Matrixx A2 | | | | | | | | | | J | K | L | M | N | O | | | | | | | 1.8395455 |
| 10, bluephase, Matrixx A3 | | | | | | | | | | J | K | L | M | N | O | P | | | | | | 1.8090741 |
| 20, Mini LED, Matrixx A3 | | | | | | | | | | | K | L | M | N | O | P | Q | | | | | 1.7735000 |
| 10, Smartlite IQ, Matrixx A3 | | | | | | | | | | | K | L | M | N | O | P | Q | | | | | 1.7638889 |
| 10, Coltolux LED, Matrixx A3 | | | | | | | | | | | | L | M | N | O | P | Q | R | | | | 1.7185185 |
| 10, Allegro, Matrixx A2 | | | | | | | | | | | | | M | N | O | P | Q | R | S | | | 1.6869697 |
| 10, Coltolux LED, Matrixx A2 | | | | | | | | | | | | | | N | O | P | Q | R | S | | | 1.6719697 |
| 10, Mini LED, Matrixx A3 | | | | | | | | | | | | | | N | O | P | Q | R | S | | | 1.6683333 |
| 10, Ultra-Lume 5, Matrixx A2 | | | | | | | | | | | | | | | O | P | Q | R | S | | | 1.6574242 |
| 10, Mini LED, Matrixx A2 | | | | | | | | | | | | | | | | P | Q | R | S | T | | 1.6415152 |
| 10, Allegro, Matrixx A3 | | | | | | | | | | | | | | | | | Q | R | S | T | | 1.5925926 |
| 10, Ultra-Lume 5, Matrixx A3 | | | | | | | | | | | | | | | | | Q | R | S | T | | 1.5870370 |
| 10, Smartlite IQ, Matrixx A2 | | | | | | | | | | | | | | | | | | R | S | T | | 1.5463636 |
| 10, Radii, Matrixx A2 | | | | | | | | | | | | | | | | | | | S | T | | 1.5134848 |
| 10, LE Demetron I, Matrixx A2 | | | | | | | | | | | | | | | | | | | | T | | 1.4712121 |
| 10, Optilux 501, Matrixx A2 | | | | | | | | | | | | | | | | | | | | T | | 1.4243333 |
| 10, Optilux 501, Matrixx A3 | | | | | | | | | | | | | | | | | | | | | U | 1.3681670 |

and 4 show the overlay plots of the curing light units for each composite shade to display their pattern of increased depth of polymerization over time.

Among the 11 curing light units tested, three curing light units were chosen to detect the maintenance of light output over time. All three curing light units provided 40 cycles of 40-second irradiation without auto-

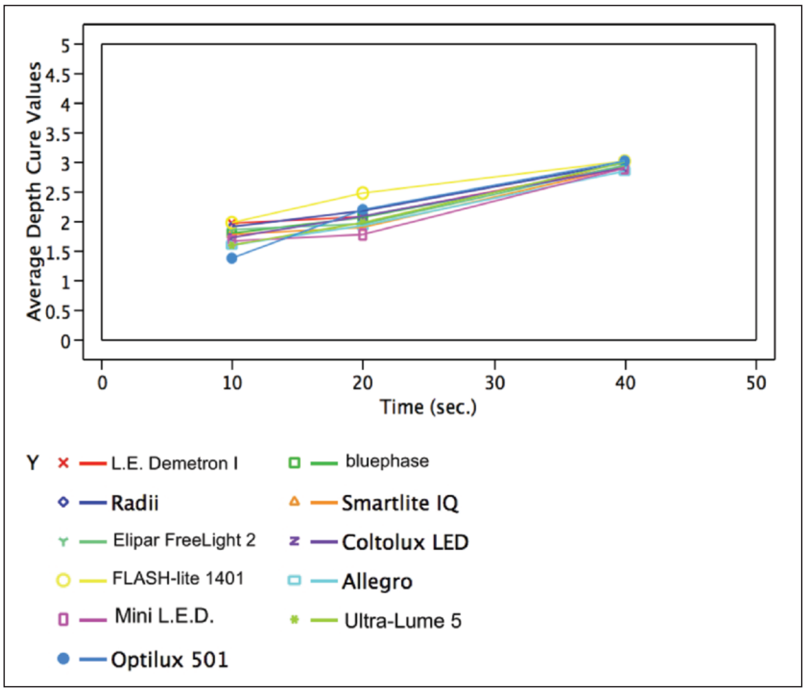


Figure 4. *Comparison between the lights in relationship to exposure time and depth of cure (mm) For Matrixx A3 posterior.*

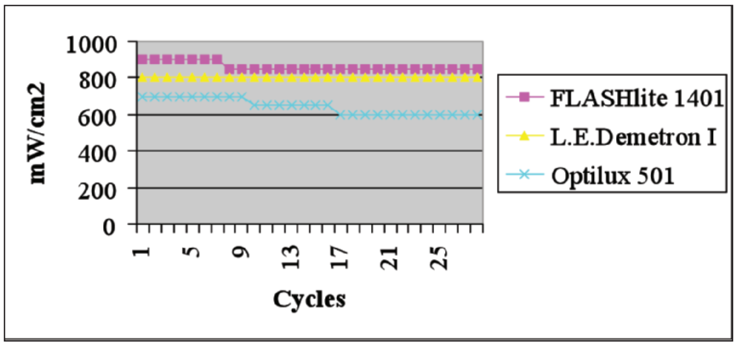


Figure 5. *Maintenance of light output in relationship to 40-second time cycles.*

matically shutting off. The starting light output of FLASH-lite 1401 was recorded as 900 mW/cm$^2$; and then dropped down to 880 mW/cm$^2$ after the eighth cycle and 800 mW/cm$^2$ after the 29$^{th}$ cycle. The light output remained the same until the end of the 40$^{th}$ cycle. The starting light output of LE Demetron 1 was recorded as 800 mW/cm$^2$ and remained the same until the end of the 40$^{th}$ cycle. The starting light output of Optilux 501 was recorded as 700 mW/cm$^2$, then dropped down to 650 mW/cm$^2$ after the 10$^{th}$ cycle and 600 mW/cm$^2$ after the 17$^{th}$ cycle. (Figure 5).

## DISCUSSION

All of the light curing units polymerized Matrixx Shade A2 anterior and A3 posterior in all time intervals based on ANSI/ADA Standard No 27. Therefore, all the units were found to be clinically acceptable in polymerizing the same resin composites. The overall results indicated that FLASH-lite 1401 was significantly superior to the rest of the lights in polymerizing both resin composites in 10- and 20-second intervals. As shown in this study, an exposure time of 20 seconds or longer assures more complete depth of cure.

The current study was designed to use one curing light unit at a time to allow each light to cool down completely. This approach was chosen to assure complete cool down of the light bulb and also maintain light output at the same level throughout the study.

Compared to the other curing light units, the Optilux 501 and FLASH-lite 1401 were found to be superior at the 40-second interval. However, the performance of Optilux 501 was inadequate at the 10-second interval, but its performance increased at the 20-second interval. Among the other LED curing light units tested, 1-lite 1401 consistently performed in a superior manner for all time intervals (Tables 5 and 6).

Significant differences among the composite shades also suggest that, regardless of the curing light used, a longer exposure time for darker shades will assure complete depth of cure, particularly in the Class II restorations. This finding was consistent with previous studies.[18-19] Therefore, in addition to longer exposure time, it is clinically advisable to use lighter shades of composite in deeper locations of preparations, such as a gingival margin of the proximal box.

One of the disadvantages of some second-generation LED curing light units was that the light unit itself heated up after a certain period of operation time. This may cause the light output to degrade and/or the units to shut off automatically. This can cause inconvenience when operators use the curing light for an extended period of time, such as for orthodontic practices when numerous brackets are cemented at one time. It is important for today's dental practice to have a curing light unit that can function without any significant degradation of light output due to overheating. Also, during some long dental procedures, such as polymerizing a number of porcelain veneers, some curing light units heat-up and can even shut-off due to poor battery life. Having a cordless curing light unit with a lithium-ion battery for enhanced operation time and an improved heat management system are attributes to be considered when making purchase decisions. Further studies are needed to determine the effect of the heat generated by these new, high-powered LED curing light units on natural teeth when polymerizing resin composite restorations.

## CONCLUSIONS

Based on ANSI/ADA Specification No 27, all of the curing light units produced an acceptable level of polymerization after 20 seconds of curing time on both composite shades. However, optimal resin composite polymerization occurred at the 40-second interval for all of the curing light units tested.

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