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Evaluation of Light Intensity Output of QTH and LED Curing Devices in Various Governmental Health Institutions

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Clinical Relevance

Evaluating the intensity of a light curing unit regularly prior to the application of tooth-colored restorative materials is essential to assure the quality of restorative procedures.

SUMMARY

The purpose of this study was to evaluate the light intensity output of quartz-tungsten-halogen (QTH) and light emitting diode (LED) curing devices located at governmental health institutions in Riyadh, Saudi Arabia.

Eight governmental institutions were involved in the study. The total number of evaluated curing devices was 210 (120 were QTH and 90 were LED). The reading of the light intensity output for each curing unit was achieved using a digital spectrometer; (Model USB4000 Spectrometer, Ocean Optics Inc, Dunedin, FL, USA). The reading procedure was performed by a single investigator; any recording of light intensity below 300 mW/cm^2 was considered unsatisfactory.

The result found that the recorded mean values of light intensity output for QTH and LED devices were 260 mW/cm^2 and 598 mW/cm^2, respectively. The percentage of QTH devices and LED devices considered unsatisfactory was 67.5% and 15.6%, respectively. Overall, the regular assessment of light curing devices using light meters is recommended to assure adequate output for clinical use.

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INTRODUCTION

The advanced evolution of esthetic restorations, including resin-based composite materials, resulted from patients' high esthetic demands.[1-7] Currently, resin-based composite materials are classified based on their polymerization into auto-polymerized (chemically-activated) or light-polymerized (light-activated).[8,9]

The visible light-polymerized resin-based composites are the most commonly used materials for both anterior and posterior direct restorations.[10,11] These resins consist of multiple components, including photo-initiators. A popular example of a photo-initiator is camphorquinone, which reacts with an amine-reducing agent when it becomes activated with a specific light wavelength.[12] The outcome of this reaction results in the formation of free radicals, initiating polymerization of the composite resin.[13]

The exposure of resin-based composites to a blue visible light with proper wavelength and sufficient energy density (ranging from 8-16 J/cm^2) will achieve proper polymerization for these materials.[14,15] The wavelength of light that reacts with camphorquinone is in the range of 400 to 500 nm. Light, passing through a resin material, is absorbed and scattered throughout the material.[15] This results in a more polymerized composite material at the surface when compared with the deeper part of the same increment.[12,16-18] Ideally, clinicians and dental assistants should examine the intensity of the light curing devices using a radiometer that measures the wavelength in a range of 400 to 520 nm.[19-21]

Quartz-tungsten-halogen (QTH) curing lights were the standard for clinical use due to their dependability and satisfactory performance until the late 1990s. The light intensity from QTH light sources can range from 400 to 1200 mW/cm^2, depending on the manufacturer and the diameter of light guide used, with a wavelength range from 390 to 520 nm.[22,23]

The QTH light has been a very useful tool in dentistry; however, extensive research has led to the development of a new light source using light emitting diodes (LED). This was first developed by Mills and colleagues in 1995.[24] LED technology has a life span of about 10,000 hours. The light has a narrower spectrum than QTH lights but is within the range required (400–500 nm) for camphorquinone (when used as the photo-initiator) to polymerize the resin-based composites.[24] Because different photo-initiators absorb the light at a different spectrum, earlier generations of LED curing lights were not able to fully polymerize resin. However, current generations of LED units have developed multiple peaks in a wider spectrum to cover different types of photo initiators.[11]

Regular evaluation of the light intensity for curing units has been evaluated and advocated in several studies.[25-29] In 1994, Barghi and his colleagues[25] evaluated the light intensity output of 209 curing units in various private dental clinics in Texas, United States, using a radiometer, and they found that 30% of the evaluated units produced inadequate light intensity. Their study indicated that dentists and dental assistants may not be aware of the quality and performance of their light curing units. Additionally, dentists may neglect the importance of regular replacement of the bulbs in the light curing units.[25]

In 1998, a similar study was done in Australia.[26] The study found that more than 50% of the evaluated 214 curing units produced inadequate curing light with an intensity output less than 300 mW/cm^2 (the minimum required intensity).[26] Other studies shared similar findings and they recommended regular maintenance and checkup of the light curing units.[27-29]

The aim of this study was to evaluate the light intensity output of QTH and LED curing devices located at various governmental health institutions in Riyadh, Saudi Arabia.

MATERIALS AND METHODS

A total of eight governmental health institutions were included in this study. All the institutions were located in Riyadh, Saudi Arabia. The study was initiated after an official process and agreement was achieved between the investigators and the institutions' administrators to get their cooperation. Two hundred fourteen dental light curing devices were evaluated at these institutions. Reading the light intensity output of each curing unit was performed using a digital spectrometer (Model USB4000 Spectrometer, Ocean Optics Inc, Dunedin, FL, USA). This model consisted of four main parts: a fiber optic integrating sphere that collected the light; a fiber optic line that connected the sphere to the third part, the spectrometer; and finally, the spectrometer that was connected to a computer with Ocean Optics SPECTRASUITE operating software installed to analyze and read the collected data. The type of the light curing unit tested (QTH or LED), age of use, and institution identity were recorded on a standardized form. Prior to the start of this survey, a pilot study was done to standardize the measurement methodology, and to train one investigator to collect the data under the supervision of the others.

Table 1: *Distribution of Acceptable/Nonacceptable Light Intensity for Tested Curing Devices With Their Mean Values*

Curing Devices	Light Intensity, mW/cm²					Mean of Light Intensity, mW/cm²
	< 300 Non-acceptable		≥ 300 Acceptable		Total	
	N	%	N	%		
QTH	81	67.5	39	32.5	120	260
LED	14	15.6	76	84.4	90	598

Abbreviations: LED, light emitting diode; QTH, quartz-tungsten-halogen.

Each unit was turned on and allowed to run for one minute before measuring the intensity to assure full power. Each light curing tip received a swab with disinfectant solution to make sure that no debris interfered with light transmission, and the diameter of the tip was measured. The Fiber Optic Integrating Sphere opening was 9.5 mm in diameter, and any curing tip with a diameter more than 9.5 mm was excluded from this study. A metal tray was fabricated with different diameter openings, including 4, 5, 6, 7, 8, and 9 mm diameters. This metal tray was positioned at the sphere opening, and the tip was placed at a right angle to its center to gain the best possible reading, as instructed by the spectrometer manufacturer. This integrating sphere then collected the energy coming from the light curing units and funneled that light to an optical fiber which was connected to the spectrometer. For each device tested there were three separate measurements of 20 seconds duration each. The three readings were recorded and the average was calculated. As per the manufacturer recommendation, the evaluation was made in a dark room for better and more accurate measurements. The reading procedure was performed by a single investigator; any recording of light intensity below 300 mW/cm^2 was considered unsatisfactory.

RESULTS

The 210 devices that matched the criteria for evaluation included 120 QTH devices (57.14%) and 90 LED devices (42.86%). The mean light intensity value for all combined devices was 407 mW/cm^2, with a range from 2 to 986 mW/cm^2; the mean value of the wavelength peak was 467 nm, with a range from 438 to 556 nm. The readings of 95 (45.2%) curing devices were below 300 mW/cm^2, whereas the readings of 115 (54.8%) curing devices were at or above 300 mW/cm^2, which was clinically acceptable for use.

The light intensity values for the QTH curing devices ranged from 6 to 795 mW/cm^2, with a mean of 260 mW/cm^2. Only 39 (32.5%) QTH curing devices passed the 300 mW/cm^2 cutoff, whereas 81 (67.5%) devices were considered clinically unacceptable, as shown in Table 1 and illustrated in Figure 1. Of the 120 QTH devices evaluated, one device had been used for less than one year, three devices had been used for one to three years, and 116 had been used for more than three years.

LED devices were found to have different data when compared with the QTH devices. Their light intensity values ranged from 2 to 986 mW/cm^2, with a mean value of 598 mW/cm^2. Seventy-six (84.4%) LED curing devices passed the 300 mW/cm^2 cutoff, whereas only 14 (15.6%) devices were considered clinically unacceptable, as shown in Table 1 and illustrated in Figure 1. Approximately 45% of the LED devices evaluated had been used for less than one year, 33% of devices had been used for one to three years, and 22% had been used for more than three years.

DISCUSSION

Resin-based composite restorations are currently the most preferred by patients and frequently placed by clinicians.[5,7,11,22,30] These restorations are dependent on many dentist- and patient-related factors to be successful, such as exposure to an adequate light

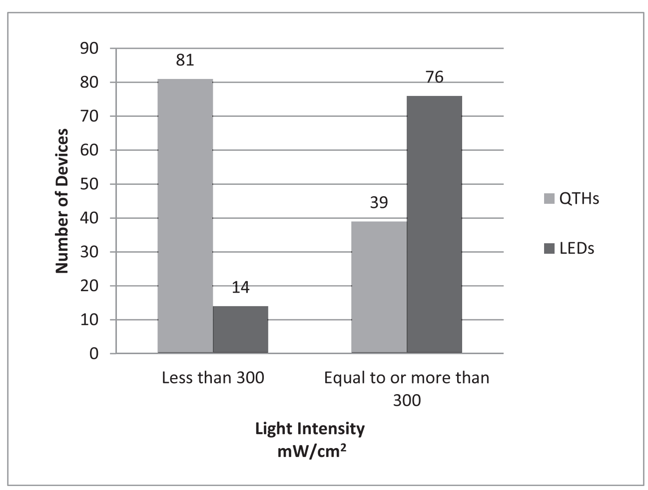

Figure 1. *The number of QTH and LED curing devices in relation to acceptable/nonacceptable light intensity.*

curing source, oral hygiene, and location and size of the prepared cavity.

The intensity of the dental light curing device needs to be high enough to initiate and assure adequate polymerization of the resin-based composite restorations. The literature indicates that light intensity values ranging from 200 to 600 mW/cm^2 are needed to achieve an adequate polymerization of resin-based composite and it is also dependent on the exposure time used for polymerization.[25-29,31-33]

The decision to have a fixed minimum light intensity value is dependent on many factors, including increment thickness, shade of the resin-based composite material, exposure time, distance of the material from the light source, curing through different materials, and wavelength region of the light. According to ANSI/ADA Specification No. 48-1-Visible Light Curing Units: 2004 and ANSI/ADA Specification No. 48-2-LED Curing Lights: 2010 "The light radiance existent in the 400 nm to 515 nm wavelength region should be no less than 300 mW/cm^2." Therefore, the minimum value of light intensity selected to be acceptable and able to polymerize a wide variety of shades of resin-based composite at a 2-mm incremental thickness within 30 to 40 seconds of exposure time is no less than 300 mW/cm^2.[31,33,34]

The selected sample in this current study was from various governmental health institutions in the Kingdom of Saudi Arabia, which is unlike previous studies. The reason for this selection is that dental treatment is free in these institutions; therefore, 80% of dental treatments are done in these institutions.[35]

Most similar studies in the literature included only QTHs. In the current study, the collected data included two different types of light curing devices (QTHs and LEDs), and the results showed that the combined mean value of light intensity for both types of devices was 407 mW/cm^2. When the mean value of light intensity for QTH curing devices in this current study is compared with that of the study of El-Mowafy and others,[28] the mean value was lower by almost one half (260 mW/cm^2 vs 526 mW/cm^2). On the other hand, the present study showed that the number of adequately performing devices used in Riyadh dental clinics were superior when compared with the study in India (32.5% vs 10%).[36] It is very clear that the principal element in having different values from different studies is related to the quality of care and maintenance for these devices.[37]

The results of this study showed that the QTH devices (57.14%) are more dominant in numbers when compared with LED devices (42.86%). The reasons for this dominant use of QTH devices include factors such as having a longer track record of success when working with resin composites and having a lower price when compared with the earlier generations of LEDs. On the other hand, the current results showed that 61 of the LED curing devices had been purchased in the last 3 years, compared with only four QTH devices. The higher percentage of LEDs being purchased in the last three years (94%) could be related to these institutions' decision makers, who found that the current generation of LEDs was satisfactory for both clinical and financial reasons. There has been a debate in the literature whether or not dental offices should shift totally to LED technology. This shifting could be related to many advantages; including less curing time (10–20 seconds), less heat generation, less maintenance needed, and satisfactory curing outcomes.[38,39]

The results of this study showed that earlier LEDs had lower intensities when compared with current ones ($p<0.0001$). A major reason for such a difference is related to the improvement of current LEDs, including a higher light intensity ranging from 500 to 1400 mW/cm^2 and a broader spectrum of light.[11,40]

CONCLUSION

Within the limitations of this present study:

1. QTH curing devices still have a greater share of usage in governmental institutions, although a higher percentage of LED curing devices have been purchased in the last three years.
2. The mean value of light intensity was higher for LED devices than for QTH devices.
3. A higher percentage of QTH devices fell below the satisfactory value of light intensity (300 mW/cm^2).
4. Overall, the regular assessment of light curing devices using light meters is recommended to assure adequate output for clinical use.

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