

Original Article

Types of polymerisation units and their intensity output in private dental clinics of twin cities in eastern province, KSA; a pilot study

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المخلص

أهداف البحث: تُعتبر الحشوات التركيبية ذات الأساس الراتنجي المعالجة بالضوء هي الخيار المفضل لترميم الأسنان. ينبغي على وحدات المعالجة الضوئية المستخدمة للأسنان أن توفر طاقة ضوئية كافية لضمان خواص ميكانيكية جيدة وثبات الأبعاد والتوافق الحيوي مع الحشوات التركيبية ذات الأساس الراتنجي. وكان الهدف من هذه الدراسة هو تحديد أنواع وحدات المعالجة الضوئية وكثافة إخراجها الضوئي في عيادات الأسنان الخاصة.

طرق البحث: تم استحداث نموذج لتسجيل المعلومات المتعلقة بنوع مصابيح المعالجة وكثافة إخراجها الضوئي. تم تقييم ما مجموعه ٤٠٠ جهاز علاج باستخدام مقياس إشعاع رقمي في ٥٨ عيادة أسنان خاصة. وأخذت ثلاث قراءات منفصلة مدة كل منها ١٠ ثوانٍ لكل جهاز وتم احتساب المتوسط. واعتبرت كثافة إخراج أقل من ٣٠٠ ميجاواط لكل سم مربع بالنسبة لوحدات الهالوجين غير مرضية، بينما اعتبرت القراءة غير مرضية لوحدات الصمام الثنائي الباعث للضوء إذا كانت أقل من ٦٠٠ ميجاواط لكل سم مربع.

النتائج: من بين ٤٠٠ مصباح علاجي، كان هناك ٣٥٤ مصباح صمام ثنائي الباعث للضوء و٤٦ وحدة مصباح هالوجين. واعتبر ما مجموعه ١٣٪ من المصابيح غير مرضية. كانت الكثافة الضوئية في ١٢.٤٪ من وحدات الصمام الثنائي الباعث للضوء أقل من ٦٠٠ ميجاواط لكل سم مربع، في حين كانت الكثافة الضوئية في ١٧.٣٪ من وحدات الهالوجين أقل من ٣٠٠ ميجاواط لكل سم مربع.

الاستنتاجات: أظهرت دراسة وحدات المعالجة الضوئية أن هنالك توجه في اتجاه وحدات العلاج الضوئي من نوع الصمام الثنائي الباعث للضوء في عيادات

الاسنان الخاصة، في حين أن قيمة الكثافة الضوئية المتوسطة الصادرة من وحدات العلاج الضوئي من نوع الصمام الثنائي الباعث للضوء كانت أعلى من تلك الصادرة من وحدات الهالوجين. ويعتبر مقياس الإشعاع، بشكل عام، أداة جيدة لتقييم الكثافة الضوئية الصادرة من وحدات العلاج الضوئي.

الكلمات المفتاحية: الصمام الثنائي الباعث للضوء؛ الهالوجين الكوارتزي التلغستي؛ مقياس الإشعاع؛ الحشوات التركيبية الراتنجية

Abstract

Objectives: Light-cured resin-based composites (RBCs) are the preferred option to restore teeth. Dental light-curing units (LCUs) should deliver adequate light energy to ensure good mechanical properties, dimensional stability, and biocompatibility of the RBC. The aim of this study was to determine the types of LCUs and their intensity output in private dental clinics.

Methods: A form was developed to record information related to the type of curing lights and their intensity output. A total of 400 curing devices were evaluated using a digital radiometer in 58 private dental clinics. For each device, three separate 10-s readings were taken and the average was calculated. For quartz tungsten halogen (QTH) units, a light intensity below 300 mW/cm² was considered unsatisfactory, whereas for light-emitting diode (LED) units, a reading below 600 mW/cm² was considered unsatisfactory.

Results: Out of 400 curing lights, 354 were LEDs and 46 were QTH units. A total of 13% of the lights were considered unsatisfactory. Of the LED units, 12.4% had a light intensity of less than 600 mW/cm², whereas QTH

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had 17.3% units with an intensity of less than 300 mW/cm².

Conclusion: The frequency of LCUs showed a trend towards LED units in private dental clinics, whereas the mean intensity value from the LED was higher than that from QTH units. Overall, the radiometer is a good tool to assess the intensity output of LCUs.

Keywords: Light-emitting diode; Quartz tungsten halogen; Radiometer; Resin composite

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Introduction

Caries prevalence in KSA has been reported to be up to 91–98%, which is considered to be a high percentage¹; thus, restorative dentistry is considered one of the most important aspects of dental clinics in KSA. Light-cured resin-based composite (RBC) is one of the most highly preferred options to restore both anterior and posterior teeth² over amalgam restorative material,³ as they can provide better aesthetics and have a command set by the operator during placement.⁴ The longevity and clinical performance of RBC restorations is dependent on multiple factors and is mostly associated with the use and efficiency of light-curing units (LCUs).^{5,6}

In the United States, 94% of dentists reported their dependency on visible LCUs to cure RBC restorations.⁷ The mode of curing has gradually changed over the last 30 years.⁸ Compared to self-cured composites, the polymerisation of RBC can be initiated by the dentist and is considered a major advantage over other restorative materials.⁹ To polymerise RBC and change it to a solid restorative material that can withstand the challenges of the oral cavity, adequate light intensity in the correct wavelength must be delivered to the restoration.¹⁰

The quality of the energy directed to RBC restorations can be affected by multiple factors, such as the intensity of the light source, the exposure duration of light from LCU to resin, distance between the surface of the resin and the curing tip, and wavelength range.¹¹

Commercially, a photo-initiating system for dental applications is based on camphorquinone (CQ) and different amines (AH). The light absorbed in the ultraviolet (UV) region by CQ is in the range of 200–300 nm, whereas at 467 nm, light will be absorbed in the visible-light region.¹² There are four types of polymerisation sources: quartz tungsten halogen bulbs (QTH), plasma arc lamps, argon ion lasers, and light-emitting diodes (LED).⁹ QTH and LED are the most famous types of LCUs used in dental clinics.¹³

The dental LED polymerisation lights produce a narrow spectrum of blue light in the 400–500-nm region and the peak wavelength is approximately 460 nm. The QTH

produces blue light in the 400–500 nm region and the intensity ranges between 400 and 600 mW/cm². According to ISO4049, LED and QTH can provide more than enough output to overcome the minimum requirements of the composite's depth of cure.¹⁴ The degree of curing throughout the bulk of RBC is acknowledged to play a significant role in its clinical success. Techniques such as layered buildup of the restoration in 2-mm increments has been suggested to achieve good polymerisation.¹⁵ Plasma arc curing (PAC) light sources provide intensities greater than 500 mW/cm², and manufacturers claim that the light polymerisation provided by PAC for 3 s is equal to that of 30–40 s of a conventional QTH curing light. However, this rapid curing is controversial, and inadequate polymerisation and microleakage has been reported.¹⁶ Argon ion lasers are effective in polymerising RBC with wavelengths ranging 450–500 nm; however, because of their smaller light size (spot size), if the restoration is larger than the tip, then the curing cycle needs to be overlapped.¹⁷ Due to these limitations and because it is expensive, the use of PAC and argon ion lasers is not common in private dental practices.

The properties of resin composite, such as the mechanical properties, solubility, dimensional stability, change in colour, and biocompatibility, can be impaired or reduced if the intensity of the LCU is insufficient.¹⁸ Many dentists are unaware of the output of their curing lights. A study performed in Japan in 1998 reported that the light intensity of LCU in private clinics was up to 82.1% less than that of brand-new units.¹⁹

There has been no study in the literature so far, to our knowledge, in the eastern province of private dental clinics showing the types of LCU and their intensity output. Therefore, the aim of this study is to determine the types of LCUs, along with their intensity output, used in private dental clinics of Khobar and Dammam, KSA.

Materials and Methods

This study was carried out in private dental clinics of the twin cities of Khobar and Dammam in the eastern province of KSA. A total of 58 private dental clinics were selected by systemic random sampling. Once ethical approval was obtained from the College of Dentistry, Imam Abdulrahman Bin Faisal University, Dammam, KSA, private dental clinics were then visited, and informed consent was taken from their medical directors after explaining the rationale and methodology of the study. A form was devised to record information related to the type of LCUs and their intensity output. The investigator was trained by taking sample readings in the dental laboratory of dental clinics of Imam Abdulrahman Bin Faisal University. A digital radiometer (Maxima Curing Light Meter, Henry Schein, NY, USA) was used to evaluate the output intensity of the LCU in the range of 0–2000 mW/cm². In total, 400 devices were evaluated at these clinics. The reading procedure was performed by a single investigator for uniform results. Each unit was turned on and allowed to run for 20 s before measuring the intensity to ensure full power was reached. The tip of each LCU was cleaned with an alcohol swab and visually inspected to ensure that no debris was present. This

was followed by placing the tip of the LCU in direct contact with the sensor of the radiometer. Then, three separate readings of 10 s each were taken, and the average was calculated. For QTH, a light intensity below 300 mW/cm² was considered unsatisfactory, whereas for the LED, the reading was considered unsatisfactory if it was below 600 mW/cm².

The 'Statistical Package for Social Science (SPSS) v22 Inc. was used to record and analyse the data. Descriptive statistics (frequency and percentages) were used to summarise the information. Independent sample T-test and chi-square tests were used for a comparison of the methods used and the association between influencing factors. A P-value of less than 0.05 was considered statistically significant.

Results

Figure 1 shows the distribution of the LCU. A total of 400 units were examined, out of which, 354 were LED units and 46 were QTH units. Of all the LCUs, 13% were considered clinically unacceptable. Among LED units, 12.4% (n = 44) had a light intensity less than 600 mW/cm², whereas for QTH units, 17.3% (n = 8) units had a light intensity less than 300 mW/cm² (Table 2).

Table 1 shows the comparison between the LED and QTH intensity outputs. The mean intensity output of 354 LED curing lights was 865.2 mW/cm² and that of QTH curing units was 527.6 mW/cm². The overall mean intensity output for both types was 826.4 mW/cm².

Discussion

RBC restorations have the potential to last a long time; however, these restorations are still replaced more frequently than anticipated, with an average reported duration of 6

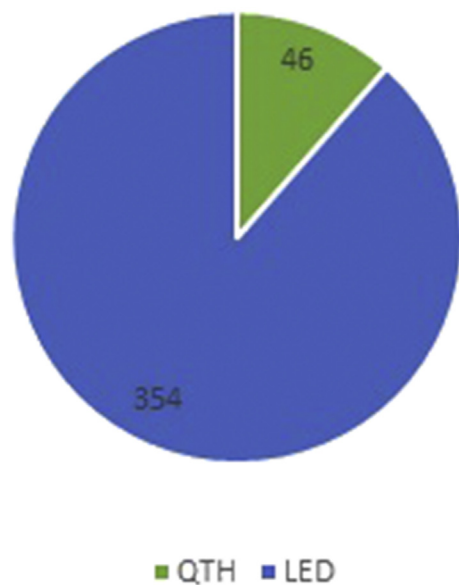


Figure 1: Distribution of polymerisation units.

Table 1: Irradiance mean values of dental private clinics for LED and QTH.

Intensity (mW/cm ²)	LED	QTH
Mean	865.2	527.6
Min–Max	93–1700	275–1021

Table 2: Comparison of LED vs. QTH intensity.

	Polymerisation units		Total (%)
	LED (%)	QTH (%)	
Inadequate Intensity	44 (12.4%)	8 (17.4%)	52 (13.0%)
Adequate Intensity	310 (87.6%)	38 (82.6%)	348 (87.0%)
Total	354	46	400

P-value = 0.347; chi-square test reveals insignificant difference of low light intensity in comparison of polymerisation techniques (LED vs. QTH).

years for replacement.⁵ One of the reasons for these restoration failures can be attributed to the inefficiency of LCU leading to inadequate polymerisation.⁵ Using an inadequate light source to polymerise RBC leads to compromised restorations.²⁰ If the polymerisation is not adequate, it will affect the bond strength, which can lead to marginal breakdown, allowing microorganisms to migrate between the tooth and restoration. This leads to secondary caries.²¹

There are multiple factors that play a role in the success of RBCs, such as the type of LCU used, exposure, thickness of the restoration, oral hygiene, and location. The intensity of LCU is also an important factor to achieve an adequate polymerisation of these restorations. According to the literature, the intensity of these curing units to achieve adequate polymerisation should be in the range of 300–600 mW/cm².^{22–25} Therefore, 300 mW/cm² should be considered the minimum intensity value to polymerise 2-mm-thick RBCs over 30–40 s.^{24–26}

In this study, the minimum acceptable intensity for QTH was set at 300 mW/cm². The American National Standard Institute and American Dental Association (ANSI/ADA) supported this in 2004, stating that, 'The light radiance existent in the 400- to 515-nm wavelength region should be no less than 300 mW/cm²'. However, the minimum acceptable intensity for LED was set at 600 mW/cm² as the LED generally require less time to cure.¹³

A literature review indicated that the average number of LCUs evaluated in private dental practices ranged between 95 and 295, which is far less than our study where 400 LCUs were evaluated. Our study showed that a total of 13% of the units tested had inadequate intensity. In a study by ElMowafy et al., 12% of the tested units had an output value below 300 mW/cm².²⁷ Maghaireh et al. reported that 46% of the units tested had an intensity less than 300 mW/cm²,²⁸ whereas Hedge et al. reported the QTH and LED values separately, with 98% of QTH lights and 90% of LED lights having output less than 400 mW/cm².²⁹ Santos et al. showed 48%²³ and Barghi et al.³⁰ reported 30% of LCUs having output intensities less than or equal to 200 mW/

cm², with both of these studies carried out in private dental practices. Moreover, a recent study by Omidi et al., in 2018 evaluated the LCUs in private dental practices in Qazvin, Iran, and reported that 93% of LED and 97% of QTH units had the desirable light intensity output, i.e., output equal or greater than 300 mW/cm².³¹

In comparison with the government and teaching institutes, AlShaafi³² reported 67.5% QTH and 15.6% LED units with intensity outputs less than 300 mW/cm², whereas Al-Samdani et al.³³ found 77.2% of LCUs with an intensity above 300 mW/cm². Another study by Ab Rahman et al.³⁴ reported that 92% of cordless LED curing units had an output intensity of more than 400 mW/cm², whereas 72.7% of QTH and 42.5% of cabled LED curing units showed an intensity output greater than 400 mW/cm². In a recent study at the government dental institute, the majority of LED and QTH LCUs showed a light intensity above 300 mW/cm².

In this study, the mean intensity for LED lights was 865.2 mW/cm², which is greater than that found in a study in Riyadh, in which the mean intensity for LED lights was 598 mW/cm². Moreover, in our study, the mean intensity of QTH was 527.6 mW/cm², which is, again, greater than the aforementioned results with a mean intensity of 260 mW/cm² for QTH.³²

Our study showed that the mean intensity values for both QTH and LED were greater than the minimum light intensity limit, i.e., 300 mW/cm², for composite to be cured consistently when placed in incremental layers, whereas for bulk-fill composite, the light intensity recommended for optimal curing is more than 1000 mW/cm² for 10 s or 600 mW/cm² for 20 s. Most of the mean values of the LED units are above the range to cure bulk-fill composite, whereas QTH will not be able to perform this task, even at 20 s. It is noteworthy to mention that operators should be aware of their light intensity in order to make use of curing lights accordingly for the desired results and can run an extra curing cycle to avoid risks when performing bulk-fill composite.

The study conducted by AlShaafi³² in Riyadh showed a low distribution of LED units (42.86%) compared to the present study, where the distribution of LED units was 88.5%. This high distribution of LED units is in harmony with the field study analysis of Switzerland, which showed a 67.10% distribution for LED lights,³⁵ and the same trend was reported by a recent study by Omidi et al. in private dental practices, with a 64.2% prevalence of LED units.³¹

On the other hand, the distribution of QTH in the present study was minimal at 11.5%, which is again similar to the field study analysis in Switzerland, showing 32.9% QTH units,³⁵ and the study by Omidi et al. showing 35.8% QTH units.³¹

One of the possible reasons for this high distribution of LED units in our study, the field study in Switzerland, and the study by Omidi et al. could be owing to the evaluation of LCUs in private dental practices compared to the study done by Alshaafi,³² which was carried out in governmental health institutes. In private clinics, the LED curing lights can be considered economical, as they have the advantage of being efficient in terms of the light production from electricity and being cordless, portable, silent, and lighter in weight compared to their substitutes, and their lifetime can reach approximately 10,000 h.^{16,36} However, in government institutes, there is generally no preference for

the selection of curing lights, and it is mostly dependent on the availability of the lights with the supply company. Moreover, government institutes might take time to become equipped with the latest and most updated facilities.

Recently, the result of a government dental school in Jeddah, 2018, showed similar trends to our study with LED curing lights being more prevalent (82.9%) than (17.1%), thus indicating a change in preference towards LED units over QTH units over time in dental institutes as well.⁴

Limitations

This study used a conventional radiometer, which displays the intensity output only of the LCU; however, no information is provided regarding the wavelength of the visible light. To overcome this limitation, a laboratory-based spectrometer should be used to evaluate the intensity and wavelength of the curing lights simultaneously.

Conclusion

The distribution of LCUs showed a trend towards LED units in private dental clinics due to their advantages over QTH lights. The mean intensity value for LED units was higher than that of QTH units. Both LED and QTH lights were suitable for curing RBCs. Finally, the radiometer is a good device to access the quality of LCUs.

Conflict of interest

The authors have no conflict of interest to declare.

Ethical approval

Ethical approval was obtained from the institutional research and ethics committee of college of dentistry, Imam Abdulrahman Bin Faisal University, Dammam, KSA.

Authors' contributions

TA, MAG, AK and SA have contributed equally to the conception and design of the study, conducted research, provided research material, collected and organised data, and analysed and interpreted data. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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