ORIGINAL ARTICLE

LIGHT CURING UNITS AND THEIR INTENSITY OUTPUT IN DENTAL SETUPS OF ISLAMABAD AND RAWALPINDI

Ahmed Usman Ashfaq[1], Muhammad Ali Faridi[2], Usman Anwer Bhatti[3], Abdul Khabeer[2]

[1]Department of Operative Dentistry, Islamabad Medical and Dental College, Islamabad-Pakistan
[2]Department of Restorative Dental Sciences, College of Dentistry, Imam Abdulrahman Bin Faisal University, Dammam-Saudi Arabia.
[3]Department of Operative Dentistry, Islamic International Dental College, Riphah International University, Islamabad-Pakistan

Background: Dental composites are commonly used to restore teeth. However, to ensure adequate physical properties and biocompatibility, they require sufficient light intensity with the help of light curing units (LCU). This study aimed to evaluate the type and intensity of LCU being used in the dental setups of Rawalpindi and Islamabad. **Methods:** Dental clinics were visited and the type of the LCU was noted. Three consecutive intensity measurements were taken using a radiometer. For Quartz tungsten halogen (QTH) LCU, a light intensity below 300mW/cm^2 was considered unsatisfactory, while for light-emitting diode (LED) LCU, a reading below 600mW/cm^2 was considered unsatisfactory. To analyse the difference between the output intensities of the two LCU, Mann-Whitney U test was used (p<0.05), while Fisher's Exact test was used for the association between the type of LCU and clinical acceptability of output intensity. **Results:** A total of 96 LCU were evaluated, out of which, eight were QTH and 88 were LED. A total of 16.7% LCU were considered unsatisfactory. Amongst them, 62.5% QTH had intensity less than 300mW/cm^2, while for LED, 12.5% had intensity below 600mW/cm^2. The mean intensity for LED was statistically significant compared to QTH LCU (p<0.05). A statistically significant association existed between the type of LCU and their intensity (p<0.05). **Conclusion:** A trend towards the use of LED LCU in the dental setups of Islamabad and Rawalpindi was observed. LED LCU showed greater mean light intensity than QTH LCU. Periodic evaluation of LCU using radiometers is suggested to ensure optimal intensity output.

Keywords: Curing lights; Halogen; LED; Polymerization

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INTRODUCTION

Resin-based dental composites (RBC) are one of the most widely used dental restorative material for anterior and posterior teeth.[1] A large majority of patients prefer tooth-coloured materials for the restoration of their teeth.[2] RBC are either chemically activated or light activated. Light activated RBC are most widely used in restorative dentistry due to their benefits of controlled working time and colour stability.[3]

Dental light curing units (LCU) are essential in dentistry and are used to initiate polymerization reaction in RBC by providing specific wavelengths and intensity in the form of light energy.[4] The most commonly used photo-initiating system for RBC is camphorquinone (CQ) and various amines.[5,6] Camphorquinone is yellow in color and has an effect on the color of RBC, therefore, limited concentration can be used.[5] An alternative to CQ is 1-phenyl-1, 2-propanedione (PPD) which does not produce the yellowing effect, yet has the same degree of conversion.[5,7] Light absorbed by CQ is in the range of 400–500 nm, with peak absorption at 470 nm and on these bases, LCU are developed.[4]

The polymerization of RBC is affected by intensity and duration of light delivered by the LCU, distance of the curing tip from resin surface and wavelength of light used for polymerization.[2] The four main types of LCU used in dentistry are QTH, (LED), Plasma arc curing (PAC) and argon laser units.[2,4,8] QTH and LED have been widely used in dental clinics,[9] which emit blue light in the range of 380-510nm wavelength[10].

The intensity output of LCU is characterized by its irradiance.[11] Different radiometers are used to measure the intensity output of LCU.[10] It has been reported that the output intensity of LCU has a great impact on the longevity of resin based materials.[12] Improper or insufficient light intensity results in incomplete polymerization which can compromise dimensional stability, biocompatibility and the mechanical properties of RBC.[5] The presence of uncured monomer together with compromised mechanical properties can potentially lead to pulpal irritation and secondary caries.[12,13] To prevent failure of these restorations, the RBC must be polymerized by LCU of adequate wavelength and sufficient energy density (ranging from 8-16J/cm^2).[3] To polymerize 1.5–2 mm of RBC, the minimum light intensity required is 16 joules/cm^2 which can be

achieved by delivering light of 400 mW/cm^2 for 40 seconds or 800 mW/cm^2 for 20 seconds.[12] However, according to the ANSI/ADA Specification (No. 48-1-Visible Light Curing Units: 2004), the light radiance existent in the 400–515 nm wavelength region should be no less than 300 mW/cm^2''. A study in Riyadh revealed that 67.5% of QTH LCU and 15.6% of LED LCU delivered intensity under 300mW/cm^2.[2] Another study in Nellore showed that 22% LED and 3% QTH LCU had adequate intensities (>850 mW/cm^2).[13]

Considering the reports from developed countries identifying the inadequacy of the LCU, it seems important to investigate the LCU being used by dental practitioners in a developing country like Pakistan. Therefore, the aim of this study was to evaluate the type and intensity of LCU used in dental clinics and hospitals of Islamabad and Rawalpindi.

MATERIAL AND METHODS

This study was conducted after acquiring ethical approval (IMDC/DS/IRB/163) from the institutional review board of Islamabad Medical and Dental College, Pakistan. LCU in dental clinics were selected by non-probability convenience sampling technique. A sample size of 96 was calculated using the WHO sample size calculator using an anticipated population proportion of 0.6.[2] The inclusion criteria for the study was LCU being used in dental clinics and hospitals of Islamabad and Rawalpindi, Damaged, non-functional curing lights and those with the presence of cured composite on light tip were excluded from the study. Written consent was taken from the concerned person to take part in the study. A single evaluator checked the type of LCU and recorded the output intensity. The mode on the LCU were adjusted to ensure maximum output intensity. A radiometer (Maxima Curing Light Meter Schein, NY, USA) was used for measuring the intensity of the LCU, by placing the tip of the LCU on the radiometer sensor for 20 seconds. After each reading, the radiometer was calibrated by turning the power switch into OFF and then ON position. Three consecutive readings were measured for each LCU and the mean was calculated. In accordance with the ISO (International Organization for Standards) 4049 standard, for QTH, the light intensity of more than 300 mW/cm^2 was considered satisfactory, while for LED, intensity output of more than 600 mW/cm^2 was considered satisfactory.[14]

Data were tabulated using Statistical Package for the Social Sciences (SPSS) version 21.0 and then summarized using descriptive statistics like frequency and percentages for the variable of LCU. Mean and standard deviations were used to report the continuous data of output intensity. Shapiro-Wilk test was used to assess the normal distribution of data. Mann-Whitney U test was used to analyse the difference in the output intensities recorded for each of the two types of LCU at a 0.05 level of significance. To test the association between type of LCU and clinical acceptability of output intensity Fisher's Exact Test was used.

RESULTS

A total of 96 LCUs were evaluated, out of which eight (8.3%) were QTH and 88 (91.7%) were LED units. The mean light intensity for the recorded output of LCUs is shown in table-1. The Light intensity of 80 (83.3%) LCU recorded a satisfactory output, while the output of 16 (16.7%) LCU were considered unsatisfactory. Amongst them, five (62.5%) QTH had light intensity less than 300 mW/cm^2, while for LED, 11 (12.5%) had a light intensity of less than 600 mW/cm^2 and were considered unsatisfactory (Table-1).

Shapiro-Wilk test indicated a lack of normal distribution of continuous data, W (96) =0.867, p=0.000. The mean light intensity was statistically significantly higher for LED compared to QTH (U=9, p= 0.000) (Table-1). A statistically significant association was present between the type of LCU and the clinical acceptability of output intensity (p<0.05).

Table-1: Mean±SD Intensity output of LCUs.

Intensity (mW/cm²)	QTH	LED	*p*-value
Mean±SD	267.88±90.41	748.93±136.61	0.000
Min-Max	147 – 374	170 – 1002	

Table-2: Comparision of QTH and LED Light curing units (n=96).

	Light Curing Units			
	QTH (%)	LED (%)	Total (%)	*p*-value
Satisfactory	3 (37.5)	77 (87.5)	80 (83.3)	0.001
Unsatisfactory	5 (62.5)	11 (12.5)	16 (16.7)	

DISCUSSION

A Light curing unit is an essential component of every dental office.[15] To achieve the optimum performance of resin-based materials, adequate energy must be delivered at the appropriate wavelengths from the LCU.[16] This study highlights the importance of frequent assessment of output intensities of LCU. Moreover, it reports the intensity

and proportion of different LCU being used in dental clinics and hospitals of Islamabad and Rawalpindi. An assessment of LCU in Pakistan has been done in the past, however, it had a limited sample size comprising of only QTH LCU.[17]

Studies investigating the performance of LCU in affluent countries like the USA and Canada have identified deficiencies in the performance of LCU. Barghi *et al* reported a 29.7%, while El-Mowafy *et al* identified a 12.1% of LCU with inadequate output.[18,19] The results of our study show a lower frequency of LCU with inadequate intensity output (16.7%) compared to the study conducted by Barghi *et al*. This difference can be due to the difference in the type of LCU being investigated as Barghi *et al* exclusively investigated QTH LCU.

In the current study, the proportion of LED LCU (91.7%) was more compared to the QTH LCU (8.3%). Omidi and colleagues conducted a study in Iran where they reported 64.2% of LED and 35.8% QTH LCU.[20] The high frequency of LED LCU in the current study may be attributed to a difference in sampled population and regional preferences among dental practitioners. Moreover, the continuous improvement in the LED technology since the 1990s may be contributing to the increasing adoption of these LCU by dentists in clinics and hospitals. Compared to QTH, LED has several benefits like narrow emission spectrum, specific energy density, improved curing efficiency, durability, compact device form and being energy efficient.[21,22]

The results of the present study are in agreement with studies conducted by Al Shaafi *et al*. and Theeb *et al*. who also reported a higher mean output intensity of LED compared with QTH LCU.[2,23] However, a smaller proportion of LED LCU reported inadequate output in the present study (12.5%) compared to Al Shaafi and colleagues (15.6%). An explanation for this difference could be the age and usage of the LED LCU being tested as observed by Al Shaafi that older units recorded lower output.[2] On the other hand, our study showed that the majority of QTH LCU (62.5%) performed unsatisfactorily, even though their minimum intensity output requirement was low. This could be attributed to the use of old units as they have more chances of bulb burn out leading to insufficient production of blue light.

Most LCUs used in Islamabad and Rawalpindi reported adequate intensity in accordance with the ISO 4049 standard to ensure effective polymerization of the resin-based materials. In fact, 87.5% of the LED LCU recorded an output intensity exceeding the 600mW/cm^2 mark. The recently developed LED LCU have the ability to not only generate a high output intensity but also a spectral emission profile necessary for the activation of modern photoinitiators like TPO (2,4,6-Trimethylbenzoyldiphenylphosphine oxide) and Ivocerin (dibenzoyl germanium derivative).[24]

This study was conducted using convenience sampling, so some amount of selection bias was expected as not all the LCU in Rawalpindi and Islamabad vicinity were included in the study. Therefore, the results are not the true representation of all the LCU and results cannot be applied to the whole region. Also, the duration for which these LCU were in service was not considered. As with the usage, the intensity of LCU decreases and it adversely affects the polymerization of RBC.[21] Lastly as most lights were tested from private clinics it would be expected that the usage and handling would be more favourable compared to a hospital setting and hence less likely to affect the output intensity.

CONCLUSION

It can be concluded that a higher number of LED LCU were used compared to QTH LCU in the dental clinics and hospitals of Islamabad and Rawalpindi. Moreover, LED LCU provided superior output intensity compared with QTH LCU. However, regular assessment using radiometers is suggested to evaluate the efficiency of light curing units.

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Conflict of interest:
None

AUTHORS' CONTRIBUTION

AUA: Data collection, draft manuscript, final approval. MAF: Interpretation of data, revision of manuscript, final approval. UAB: Statistical analysis, revision of manuscript, final approval. AK: Concept of study, revision and final proofreading and editing, final approval

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Address for Correspondence:

Abdul Khabeer, Department of Restorative Dental Sciences, College of Dentistry, Imam Abdulrahman Bin Faisal University, Saudi Arabia.
Email: akhabz@hotmail.com