***Case study***

# The Evaluation of the efficiency of LED Light-Curing units used in private dental clinics

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## *Abstract*

***Background and Aim :***

The light-cured composites and other restorative materials are quite common in dentistry today. Successful restorations are dependent on the efficiency of the light-curing unit, the intensity of light, and its wavelength. This study evaluated the efficiency of LED light-curing units in private dental clinics in Tehran.

**Materials and Methods**:

In this descriptive cross-sectional study, 320 light-curing devices in different private dental clinics were randomly evaluated. The radiometer (light-testing-meter) measured Light intensity, and also dust on the fan and cracks or scratches on the filter were directly observed. Moreover, the age of the device, the frequency of changing the bulbs and satisfaction of the dentist concerning the light-curing unit were recorded in questionnaires. Data were analyzed for Spearman correlation and t-test using SPSS software with $p<0.05$ as the level of significance.

***The results:***

The results showed that 53.75% of the units had intensity more than 300 $mW/cm^2$. The power of 30.3% of curing light units was between 200 and 300 $mW/cm^2$, and 15.9% had lower than200 $mW/cm^2$. The light intensity has a negative relation with the age of the unit, frequency of bulb changing, and scratches

on the filter and dust on the fan.

***Conclusion*:**

The results proved that the light intensity of about 46% of light-curing units, used in private dental practices and clinics, were inadequate. Since factors such as ageing of the light-curing devices, frequency of bulb replacement, increasing the amount of dust on the fan and scratches on the filter reduce the light intensity, and also regular quality control of these devices is necessary.

Key Words: Light curing unit; Intensity; Radiometer; Composite resin

## *Introduction*

Today, the clinical application of resin composites has increased. The success of composite restorations with light cure depends on the degree of polymerization and consequently, the light intensity output of light-curing units. Sufficient power, correct wavelength (420-520 nm), and sufficient curing time have an essential effect on sufficient polymerization of composite resins. Various factors also affect the intensity of the light output of the device (19). Changes in voltage, filter failure, pollution of light cure tip, failure of electrical components, the fracture of light transmitters (filters), the small diameter of the device, the distance between the tip of the device and tooth and the length of light-curing are significant factors (1), (2).Disinfectants containing Glutaraldehyde also cause fractures on the surface of optical glass-fiber tip leading to a decrease in the intensity of lightning (3).The dimensions and location of the dental cavity, colour and thickness of the composite play an essential role in the amount of light passing through the deep layers (1,4,5). The sufficient light intensity of curing devices is needed to achieve the maximum polymerization. Some researchers found that 300 MW for Polymerization of composite that its thickness is 2 mm is required(6). The surface hardness of the composite is not a reliable guide for evaluation of efficient curing. The level of hardening could be sufficient with low light while the deep surfaces may be poorly cured. Therefore, using a light-testing-meter is recommended to evaluate the intensity output of light-curing units. (6) In this regard, different studies have been conducted in different cities (11-8, 20). The last survey in Tehran was about 20 years ago (9). Due to new devices that are used today, the present study was conducted to evaluate the efficacy of light cure devices in private dentistry offices in Tehran.

## *Materials and Methods:*

In this cross-sectional and descriptive-analytic study, data were obtained through observation and interviews. Firstly, the information forms through asking questions from dentists and the observation of the machine were completed. These forms included the age of the device, the frequency of use of the device per day, the radiation time for each layer, number of working days of the office per week, the amount of dust accumulated on the machine's fan. Also, the presence or absence of scratches on the filter, the dentist's satisfaction or dissatisfaction with the device, and the frequency of replacing the bulbs were recorded. After turning on the device and using for 1 minute, the intensity of radiation was

measured in mW/cm$^2$ by the radiometer ( light-testing-meter) for three times. If the difference was more than25 mW/cm$^2$ after reading numbers, the measurement was repeated. Among recorded numbers, the average number was measured to obtain the final result.

The following equation was used to obtain the clinical age of the device:

Clinical age of the device = time in use (in terms of year) × 52 (number of weeks in a year) × number of working days of the office per week x The average frequency of use of the device during the day x Average exposure time in each instance of the use of the device (in terms of seconds)

Data were analyzed by SPSS software and Spearman's correlation coefficient, and also t-test. P <0.05 was considered as a significant level.

### *Results:*

The results showed that the average intensity of radiation was 432/60 mW/cm$^2$. The maximum intensity of radiation was recorded at 1000 mW/CM$^2$ and minimum intensity was 100 MW / cm2,25% of units below 260 mW/cm$^2$, 50% of them below 370 mW/cm$^2$, and 75% of the devices showed an intensity of less than 550 mW/cm$^2$. Only 5% of light-curing units was higher than 800 mW/cm$^2$.

**<u>The radiation intensity of the devices was divided into three groups:</u>**

A) The radiation intensity is higher than 300 MW/cm$^2$, which is favourable for radiation intensity. In this group, 53.75% of devices were counted.

B) The intensity of the radiation is between 201-300 mW/cm$^2$, which requires a longer exposure time to achieve the desired results. 30.3% of the devices were in this group.

C) The radiation intensity is 200 mW/cm$^2$ or less that can not be compensated for even if the exposure time is prolonged. 15.9 % of the devices were in this group.

The average age of light cure devices was 6.76 years. The frequency distribution of devices in terms of radiation intensity is given in Table 1.

**Table 1. Distribution of Clinical Age (Hours) based on** Exposure time/Light intensity relation **in Dentistry Office in Tehran**

| Radiation Intensity Mw/cm2<br>Age (Hours) | 0-200 | 201-300 | 300< | Total |
|---|---|---|---|---|
| 0-5 (hour) | 0(0%) | 0(0%) | 12(100%) | 12(100%) |
| 5-40 (hour) | 5(6.94%) | 5(6.94%) | 62(86.11%) | 72(100%) |
| 40-80 (hour) | 11(18.03%) | 16(26.2%) | 34(55.7%) | 61(100%) |
| 80-160 (hour) | 18(20%) | 32(35%) | 41(45%) | 91(100%) |
| 160-450 (hour) | 16(22.8%) | 36(51.4%) | 18(25.7%) | 70(100%) |
| 450< (hour) | 1(7.14%) | 8(57.14%) | 5(35.71%) | 14(100%) |
| Total | 51(15.9%) | 97(30.3%) | 172(53.75%) | 320(100%) |

**Table 2: Distribution of the amount of** Dust accumulation in cooling system/Light intensity relation **in dental offices in Tehran**

| Radiation intensity Mw/cm2<br>The amount of dust | 0-200 | 201-300 | 300< | Total |
|---|---|---|---|---|
| Without dust | 0(0%) | 1(4.35%) | 22(95.65%) | 23(100%) |
| With little dust | 10(6.9%) | 22(15.1%) | 113(78%) | 145(100%) |
| With more dust | 32(25.66%) | 74(48.68%) | 32(25.66%) | 152(100%) |
| Total | 51(15.9%) | 97(30.3%) | 172(53.75%) | 320(100%) |

**Table3: Frequency distribution of** replacement frequency/Light intensity relation **in dentistry offices in Tehran**

| Radiation intensity Mw/cm2<br>Lamp replacement | 0-200 | 201-300 | 300< | Total |
|---|---|---|---|---|
| 0 | 12(9.8%) | 15(12.2%) | 96(78%) | 123(100%) |
| 1 | 0(0%) | 15(20%) | 59(80%) | 74(100%) |
| 2 | 0(0%) | 28(68.3%) | 13(31.7%) | 41(100%) |
| 3 | 12 (36%) | 21 (64%) | 0(0%) | 33(100%) |

| | | | | |
|---|---|---|---|---|
| 4&more | 26(53%) | 18(37%) | 5(10%) | 49(100%) |
| Total | 51(15.9%) | 97(30.3%) | 172(53.75%) | 320(100%) |

The relationship between radiation intensity and clinical age was measured by the Spearman correlation coefficient. The results indicated that an increase in the age of the device leads to decreasing the intensity of the radiation (r = -0.214). This relationship was statistically significant (P = 0.001).

The results showed that 7.2% of the devices did not have any dust on the fan. In 45.3% of them, they had a little dust on the fan, and in 47.5% they had large dust on the fan. With increasing dust on the fan, the intensity of the radiation was reduced. (R = -0.576). This relationship was statistically significant (P <0.001). (Table 2)

Almost all dentists, participating in this study (exception of 2 people) were satisfied with the function of their device (1.99%).

According to records, 38.4% of the light-curing devices have not been changed even once. Statistical analysis showed that there was a correlation between radiation intensity and the number of bulbs(r = -0.53), and the frequency of light bulb replacement was significantly reduced (P = 0.001).

Furthermore, 45.41% of devices had a scratch or crack on the filter, and 54.58% of them did not have. Through t-test, the relationship between the light intensity of units and the scratches or cracks on the filter was investigated. Despite the cracking or scratching on the filter, the radiation intensity of the device was reduced and this relationship was statistically significant (P=0.001).

## ***Discussion and Conclusion:***

Due to the increased use of composites, the importance of polymerization has become more prominent. The strength of these restorations depends on the degree of polymerization of composite resins. Incomplete polymerization produces adverse biological effects, increasing water absorption, composite solubility, and reducing hardness. Since composite restorations are currently the most preferred by patients and frequently placed by clinicians. Various elements contribute to the polymerization of the composites, and they include the wavelength and the output intensity of light-curing units, duration of radiation, dimensions and the location of the dental cavity. Since insufficient radiation intensity is not always compensated for by prolonging the exposure time, the intensity of the radiation should be regularly monitored. The light output of the device decreases because the device is used more, but this is not detectable by the naked eye because sometimes a seemingly bright light is not suitable for wavelengths (1.6). The surface hardness of composites is not a reliable guide because even at a low light intensity, the surface can sufficiently harden while the depth of the cure is inadequate. Besides, the dentist can't distinguish completely-cured composite resin from the one incompletely cured using a

device with low light intensity (12-14). Today, there are various types of dental radiometers, used as an acceptable method for assessing the effectiveness of the devices. In the present study, a radiometer (Demetron) was used to study the light intensity of light-curing devices. The light intensity of 46.2% of the devices was lower than the optimal level, which is similar to the results of Barghi et al. (45%)( 1). However, in comparison with the results of Akhavan Zanjani et al. is lower (9).The optimal intensity of radiation is 300mW / cm2 for light-curing devices (6).

According to the study of Rueggeberg et al., the light intensity of 51 devices was less than 200 $mW/cm^2$, and they should not be used (2). The results of this study which is different from the research of Akhavan Zanjani et al. could play a vital role in increasing dentists' knowledge during the last ten years(9). The variation of light-curing devices in different countries may be due to the differences between the results of this study and those of Barghi et al. (1) and Dunne et al. (6). In this study, based on statistical records, the light intensity has been reduced by increasing the frequency of changing LED bulbs, which is similar to the results obtained from the study of Akhavan Zanjani et al. (9). By contrast, In the study of Miyazaki and his colleagues, the replacement of the bulb has dramatically influenced the light intensity of the light-curing units. He immediately examined the light intensity of devices after changing the bulbs, and increasing the clinical age of units was not considered during several times of replacing bulbs (15). However, it is possible that increasing the clinical age of units the clinical age number leads to increasing the frequency of bulb replacement, and also the effect of increasing age on decreasing the intensity of light will dominate the frequency of bulb replacement.

In the present study, the filters of light-curing units were investigated in terms of cracks or scratches, but the amount of crack or scratch has not been recorded (21). The results show that the presence of scratches on the filter has a negative relationship with the radiation intensity of the device, which was also reported in Barghi et al. (1). This can be explained by failure in filter performance and its negative effect on the output intensity of light. Regarding the amount of dust on the fans, in this study, 7.2% of them had no dust, 45.3% had low dust, and also 47.5% had large dust. While Barghi et al. recorded the less contamination on the fan and the tip of fiberoptic that it was due to the excellent care of dentists by the light cure device (1). This different result can be related to the differences in the criteria of the subjects in the measurement of infection rates. In this study, there was a relationship between dust and contamination on the fan by decreasing the radiation intensity of the device, which was also observed in Barghi et al. (1). The interesting point was that 99% of dentists were satisfied with their device, although the intensity of the radiation was not optimal. In total, this study, which included 320 Light Curing devices in private offices in Tehran in 2016, showed that: the power of about 46% of light-curing devices was less than optimal radiation intensity. The radiation intensity has been reduced with some factors such as increasing the age of devices, the frequency of bulb replacement, dust on the fan, and the presence of cracking or scratching on the filter. The majority of dentists are satisfied with their device and the surface hardness of restorations, and also are not aware of the effect of voltage fluctuations on the light intensity of the device.

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