Evaluation of the Effect of Protective Sleeve on Output Intensity of Light Emitting Diode Light Cure Units

Amit Jena[1], Satyajit Mohapatra[2], Govind Shashirekha[3]

[1] Professor, Department of Conservative Dentistry and Endodontics, Institute Of Dental Sciences, Siksha 'O' Anusandhan University, Bhubaneswar-751003, Odisha, India
[2] Post Graduate Trainee, Department of Conservative Dentistry & Endodontics Institute Of Dental Sciences, Siksha 'O'Anusandhan University Bhubaneswar – 751003, Odisha, India
[3] Associate Professor, Department of Conservative Dentistry & Endodontics Institute Of Dental Sciences, Siksha 'O' Anusandhan University Bhubaneswar-751003, Odisha, India

Received 13 January 2016 and Accepted 12 March 2016

Abstract

Aim: The purpose of this study was to compare the difference in the output intensity of Light Emitting Diode (LED) light cure (LC) devices with and without a protective sleeve and its clinical significance. **Materials and Methods**: The output intensity of 152 LC units in dental offices across the state of Odisha were examined. The collection of related information included an average number of exposures per day and the charging status. LED Radiometer (SDI Ltd, VIC, AUS) was used for measuring output intensity. **Results**: Out of all the 152 LC devices examined, 137 were found to emit light intensity above minimum baseline values when used with a protective sleeve. The decrease in output intensity, when used with a protective sleeve was statistically significant ($p<0.05$). 78 LC devices with direct current supply, maintained better intensity than battery operated ones. 74 battery operated LC devices showed statistically significant differences ($p<0.05$) in intensity output based on the number of exposures/day. Devices that were being charged daily maintained significantly ($p<0.05$) better intensity output than those being charged once or twice a week. **Conclusion**: LED Light cure devices can be safely used along with a protective sleeve to improve cross infection control without affecting its output intensity. Battery operated LED devices must be charged at least 3 times/ week to prevent a significant decrease in output intensity.

Key words: Composite, Infection control, Protective sleeve, Output intensity of LED light cure.

Jena A, Mohapatra S, Shashirekha G. Evaluation of the Effect of Protective Sleeve on Output Intensity of Light Emitting Diode Light Cure Units. J Dent Mater Tech 2016; 5(3): 120-24.

Introduction

Visible-light-activated dental resin composites have been widely used as esthetic restorative materials for anterior and posterior teeth (1). Most often, the material is blamed for the failure of the restoration rather than considering the technique/method of placement or any errors that might have arisen due to use of faulty equipment's in the restoration procedure. Both physical and biological properties of resins are affected by the degree of polymerization (2). The impact of sufficient output intensity of light cure devices in ensuring the longevity of restorations and avoiding undesirable clinical outcomes is universally accepted (3). Numerous studies highlighted the impact of sufficient curing intensity on the satisfactory clinical performance of composite resins (4-5). Early clinical failure in a composite restoration due to insufficient curing intensity may include discoloration, early fracture of restoration or pulpal irritation which can be attributed to the fact that insufficient curing intensity from light cure devices may leave unreacted monomers within the restorative material and cause pulpal symptoms (6).

The minimum light intensity to cure 1.5-2.0 mm depth of composite and achieve 50-60% of monomer conversion is approximately 16joules/cm^2. This can be achieved by a light delivering of 400 mW/cm^2 for a 40second exposure (400mW/cm^2 × 40seconds=16 J/cm^2) or a 800 mW/cm^2 for a 20second exposure.[7] The intensity of emission is reduced by debris adhered to the light guide tip, repeated sterilization of the light guide and damaged or chipped light guides.[8] In recent years, light emitting diode (LED) curing devices have gained more popularity for curing composite resins in comparison to laser or plasma arc curing (PAC) devices (9-10). The simplicity in design, reduced cost and longer and more consistent performance of the LED devices could be a more likely explanation for their increase in popularity.

In 2003, the Centre for Disease Control and Prevention (CDC, Atlanta,USA) published guidelines for Dental Healthcare Settings which emphasize that barrier protection of vulnerable surfaces and equipments can prevent contamination of objects that come in contact with patients, particularly for those that are difficult to clean such as light cure devices.[11] Dental offices must maintain a high level of infection control to protect patients and personnel; however, light guides used when curing resins are often in direct contact with oral tissues (12). A variety of infection control methods have been used to prevent cross-contamination including surface disinfection(13) autoclavable tips (14), pre-sterilized single-use disposable tips[15] and covering or wrapping the light-cure tip with a non-opaque impermeable barrier (16). Wiping with a disinfectant solution is quick and convenient, however, some studies have shown that glutaraldehyde-based solutions may reduce light transmission through a light guide or damage the fibers in it (17). Autoclaving may significantly reduce the ability of the guide to transmit light from the light cure unit to the tooth (5).

Although using a protective barrier for semi-critical instruments such as light cure tips is recommended by the National Centre for Chronic Disease Prevention and Health Promotion (CDC, Atlanta.USA), they may attenuate light transmission and impair polymerization[18]. Thus, it is essential for us to consider the output intensity of a LED curing device as well as ensuring that adequate infection control measures are taken at the same time in order to achieve a successful restoration.

The purpose of this study was to compare the difference in the output intensity of LED light cure devices with and without a protective sleeve and its clinical significance.

Materials and Methods

The survey was conducted in dental offices across the state of Odisha (India). Only working/functional LED devices of different companies, used by dental surgeons in the dental offices were included in the study for the examination of the intensity output. A total of 6 intensity scores, 3 without using any sleeve (Group I) and 3 scores using a protective sleeve (Group II) with at least 1 minute interval were taken and the average digital readouts were recorded. Portable hand held LED radiometer (SDI Ltd, VIC, AUS) was used to take the intensity output readings (Fig. 1). RVG sleeves (Reach Global India Pvt. Ltd, Pune, IND) adapted to the LED light cure devices were used as the protective sleeve. The number of devices screened was 152. Light cure devices with broken tips were excluded from the study.

Additionally, data was collected from dental surgeons about the average number of exposures per day and about charging status-daily/weekly during restorative procedures. Examination of the light cure tip for previous composite buildups was done. In cases where any composite build ups was found, Glassvan® surgical blade No. 15 (Niraj Ind. Pvt. Ltd. Faridabad, IND) was used to remove the composite resin prior to the recording of intensity scores. Information regarding the number of exposures (each 20seconds) per day was also collected (≤ 20 or >20 times per day).

The radiometer was kept on a flat surface and the intensity was recorded by activating the light cure device with its tip touching the surface of the radiometer (Fig. 2). Mean intensity was computed and statistical analysis was done, using IBM SPSS 17.0 software. Paired t-test was used to see the significance of the light cure devices with and without a protective sleeve.

Figure 1. LED Radiometer (SDI, Australia)

Figure 2. LED radiometer used to record the intensity output

Results

Mean values of light intensity with and without protective sleeves are given in (Table 1). Regarding intensity output, there was statistically significant difference between the groups (P< 0.05). Of the 152 screened LED light cure devices, 78 used a DC supply. In the cordless, battery operated devices (N=74), those being charged daily maintained significantly (p<0.05) better intensity output than those charged once or twice a week. (Table 2) 126 devices were used for ≤ 20 exposures daily while in 26 devices >20 exposures were performed every day. Out of 74 battery operated devices, 62 had ≤ 20 exposures while 12 devices had >20 exposures with statistically significant difference in intensity output based on the number of exposures/day (Table 3)

Table 1. Mean values of light intensity of LED devices (N=152)

Groups	Mean (mW/cm^2)	SD	*p*
I	1268.85	710.188	0.018*
II	1111.18	432.773	

SD= Standard deviation,
*significant difference between groups (*p*<0.05)

Table 2. Mean intensity of battery operated devices based on the charging frequency (n= 74)

Charging status	Group I (in mW/cm^2)	Group II (in mW/cm^2)
Daily	1080.7±95.1	918.33±91.8*
Thrice per week	1066.53±92.6	867.46±72.1*
Twice per week	939.17±89.3†	685.85±88.3*†
Once per week	938.165±92.6†	674.72±78.4*†

*significant difference between groups (*p*<0.05)
† significant difference within group when compared with daily charging status (*p*<0.05).

Table 3. Distribution of intensity output of battery operated LC devices based on number of exposures

No. of battery operated devices (number of exposures/day)	Group I	Group II
≤ 20(62)	1026.11±95.2	934.35±85.5*
>20 (12)	705.08±78.2†	586.35±45.7*†

*significance difference between groups (*p*<0.05)
† Significant difference within group (*p*<0.05)

Discussion

Visible light curing of light-cured materials are considered as an integral element of everyday clinical practice. Factors investigated in this study were mean output intensity with and without a protective sleeve, the effect of charging and the number of exposures on the intensity of battery operated light cure devices.

A baseline value of 400mW/cm^2 was considered in this study since it is the minimum irradiance value required to achieve 50-60% monomer conversion (7).

Irradiance values obtained by handheld radiometers are relative values and may differ between various laboratory grade radiometers (19). Hence, to standardize the intensity reading, in this study one single radiometer was used.

The evaluation method allowed assessment of the effect of protective sleeves on the output intensity of LED light cure devices. Warren DP et al. (16) found that barrier methods to prevent contamination of light cure tips cause a reduction in the output intensity of the device, however, it was not statistically significant. In our study, the output intensity differences between the groups were statistically significant (p<0.05). In Group II, the mean values (1111.18±432.773 mW/cm^2) indicate that though protective sleeves are used, the output intensity is well above the baseline value of 400 mW/cm^2.

Although the use of protective sleeves caused attenuation of light transmission, its use is highly recommended to prevent cross contamination. Additionally, it also prevents chances of composite buildups on the curing tips during restorative procedures, thereby maintaining higher output intensity. In this study mean output intensity in the presence of composite build ups on the tips (3 L.E.D units) was below the baseline values. Rueggeberg et al.(5) also have reported similar results.

Previous studies (21) have proved that the output intensity of a light cure device is also affected by tip angulation and the distance of the curing tip from the restorative material being cured.[20] Hence, in this study, the light cure tip was kept in contact with the radiometer. The effect of tip angulation was beyond the scope of the present study.

The battery operated devices with fewer exposures (≤ 20/day) displayed significantly (p<0.05) better output intensity than those with more than 20 exposures/day. This may be related to the effect of charging status. Therefore, devices with more exposure rates should be charged daily to prevent any decrease in light intensity. The devices, which used DC supply, maintained a better output intensity than the battery operated ones.

Previous studies have reported that at energy densities of more than 1700 mW/cm^2, no further improvement in mechanical properties of the composite was achieved. This leads to the conclusion that with latest generations of LED units providing output levels consistently between 1,500-2,000 mW/cm^2, polymerization time can be reduced to 20 seconds. (21)

Pulpal damage in deep cavities, due to excessive heat generated from LED light cure units has been investigated in various studies (22-23). With less than 1 mm of dentin thickness remaining, temperature rise of 5.6°C inside the pulp chamber must be considered critical (24) even in modern LED light cure devices, 93% of the total energy is converted to heat (25). Studies have shown that a moderate rise in temperature increases pulpal blood flow, which in turn compensates for the increase in temperature, however, higher temperatures result in a rapid breakdown of pulpal microcirculation (26). Other studies have shown that temperature rises do affect cellular metabolism and function even in the absence of complete destruction of cells (27-29).

The effects of other variables such as the intensity of light cure devices, curing tip size, the thickness of protective sleeves and voltage regulation are beyond the scope of this study. Further studies are needed to investigate the effect of the thickness of the sleeve, angulation of light curing tip and curing tip size on the output intensity of LED light curing machines.

Conclusion

LED light cure devices can be safely used along with a protective sleeve to improve cross infection control without affecting its output intensity. Battery operated LED light cure devices must be charged at least 3 times/week to prevent a significant decrease in output intensity. As indicated by the findings of the present study, practical aspects of increasing dependence on light cure devices must be addressed.

References

1. Kawaguchi M, Fukushima T, Miyazaki K. The relationship between cure depth and transmission coefficient of visible-light-activated resin composites. J Dent Res 1994;73:516-521.
2. Caughman WF, Rueggeberg FA, Curtis JW. Clinical guidelines for photocuring restorative resins. J Am Dent Assoc 1995;126:1280-1282, 1284, 1286
3. Pearson GJ, Longman CM. Water sorption and solubility of resin-based materials following inadequate polymerization by a visible-light curing system. J Oral Rehabil 1989;16:57-61.
4. Leung RL, Fan PL, Johnston WM. Post-irradiation Polymerization of Visible Light-activated Composite Resin. J Dent Res 1983;62:363-365.
5. Rueggeberg FA, Caughman WF, Curtis JW. Effect of light intensity and exposure duration on cure of resin composite. Oper Dent 1994;19:26-32.
6. Bouillaguet S. Biological risks of resin-based materials to the dentin-pulp complex. Crit Rev Oral Biol Med 2004;15:47-60.
7. Annusavice KJ. Phillips' Science of Dental Materials. 11th ed. Elsevier Ltd; 2006.pp:412
8. Mitton BA, Wilson NH. The use and maintenance of visible light activating units in general practice. Br Dent J 2001;191:82-86.
9. Asmussen E, Peutzfeldt A. Light-emitting diode curing: Influence on selected properties of resin composites. Quintessence Int 2003;34:71-75.
10. Barghi N, McAlister EH. LED and halogen lights: effect of ceramic thickness and shade on curing luting resin. Compend Contin Educ Dent 2003;24:497-500, 502, 504.
11. Kohn WG, Collins AS, Cleveland JL, Harte JA, Eklund KJ, Malvitz DM. Guidelines for Infection Control in Dental Health-Care Settings --- 2003. MMWR Recomm Rep. 2003;19:1-61.
12. Autio KL, Rosen S, Reynolds NJ, Bright JS. Studies on cross-contamination in the dental clinic. J Am Dent Assoc 1980;100:358-61.
13. Nelson SK, Caughman WF, Rueggeberg FA, Lockwood PE. Effect of glutaraldehyde cold sterilants on light transmission of curing tips. Quintessence Int 1997;28:725-730.
14. Rueggeberg FA, Caughman F, Comer RW. The effect of autoclaving on energy. J Am Dent Assoc 1996;127:1183-87
15. Morrow L, Wilson NH, Setcos JC. Single-use, disposable, pre-sterilized light-activation probe: the future? Quintessence Int 1998;29:781-785.

16. Warren DP, Rice HC, Powers JM. Intensity of curing lights affected by barriers. J Dent Hyg 2000;74:20-23.
17. Caughman GB, Caughman WF, Napier N, Schuster GS. Disinfection of visible-light-curing devices. Oper Dent 1989;14:2-7.
18. Coutinho M, Trevizam NC, Takayassu RN, Leme AA, Soares GP. Distance and protective barrier effects on the composite resin degree of conversion. Contemp Clin Dent 2013;4:152-155.
19. Leonard DL, Charlton DG, Hilton TJ. Effect of curing-tip diameter on the accuracy of dental radiometers. Oper Dent 1999;24:31-37.
20. Radzi Z, Abu Kasim NH, Yahya NA, Abu Osman NA, Kassim NL. Relationship of the light intensity of selected light curing units with varying distance and angulation of the light curing tip and lightmeter. Ann Dent 2008;15:33-39.
21. Ernst CP, Meyer GR, Müller J, Stender E, Ahlers MO, Willershausern B. Depth of cure of LED vs QTH light-curing devices at a distance of 7 mm. J Adhes Dent 2004;6:141-150.
22. Durey K, Santini A, Miletic V. Pulp chamber temperature rise during curing of resin based composites with different curing lights. Prim Dent Care. 2008;15:33-38
23. Santini A, Watterson C, Miletic V. Temperature rise within the pulp chamber during composite resin polymerisation using three different light sources. Oper Dent J. 2008;5:137-141
24. Bouillaguet S, Caillot G, Forchelet J, Cattani-Lorente M, Wataha JC, Krejci I. Thermal risks from LED- and high-intensity QTH-curing units during polymerization of dental resins. J Biomed Mater Res B Appl Biomater 2005;72:260-267.
25. Mills RW, Uhl A, Jandt KD. Optical power outputs, spectra and dental composite depths of cure, obtained with blue light emitting diode (LED) and halogen light curing units (LCUs). Br Dent J 2002;193:459-463.
26. Raab WH. Temperature related changes in pulpal microcirculation. Proc Finn Dent Soc 1992;88:469-479.
27. Noda M, Wataha JC, Kaga M, Lockwood PE, Volkmann KR, Sano H. Components of dentinal adhesives modulate heat shock protein 72 expression in heat-stressed THP-1 human monocytes at sublethal concentrations. J Dent Res 2002;81:265-269
28. Bornman L, Baladi S, Richard MJ, Tyrrell RM, Polla BS. Differential regulation and expression of stress proteins and ferritin in human monocytes. J Cell Physiol 1999;178:1-8.
29. Wataha JC, Lockwood PE, Lewis JB, Rueggeberg FA, Messer RLW. Biological effects of blue light from dental curing units. Dent Mater 2004;20:150-157.

Corresponding Author:
Amit Jena
Conservative Dentistry and Endodontics,
Institute Of Dental Sciences, Siksha 'O' Anusandhan University,
Bhubaneswar-751003, Odisha, India
Email: Amitjena@Yahoo.Com
Tell: 919437836499