ORIGINAL RESEARCH

Efficacy of Infection Control Barrier on Cross Contamination and its Effect on the Intensity Variation

Devarasa G Murugeshappa[1], Swarna Y Math[2], Dheeraj Kalra[3], Wong H Zhang[4], Lyster E Loo[5], Hii L Ming[6]

Abstract

Aim: To compare and assess the level of infection control provided by a cling film against a sleeve and their impact on the light intensity level of dental light-emitting diode (LED) light-curing units (LCUs).

Materials and methods: A sleeve and a cling film of proprietary brands were compared on their reduction of light output and bacterial colonies on agar plates. Including a control group, 120 samples of analog radiometer readings were obtained. A total of 90 samples, including 10 each for positive and negative controls, were obtained in a laboratory setting via swabbing of light-guiding tips placed intraorally. These swabbings were inoculated on 5% sheep blood agar in a biological cabinet and cultured for 48 hours at 37°C; the inoculated surfaces were photographed and analyzed for area of coverage by bacterial colonies. The data obtained were subjected to ANOVA and Mann–Whitney *U* tests.

Results: There is neither statistically significant reduction in output nor difference in output between either barriers ($p > 0.05$). There is statistically significant reduction in bacterial colonies on the inoculated surface by both barriers compared to no barrier ($p < 0.01$), but there is no statistically significant difference between the two barriers ($p > 0.05$).

Conclusion: Both barriers do not significantly affect light output and are equally efficacious as cross-contamination barriers, and the choice lies with the operator.

Clinical significance: Use of barriers is very important to prevent cross-infection control. The results of our study help the clinician select appropriate measures to prevent cross infection while using LCUs across the patients.

Keywords: Bacterial contamination, Cling films, Cross-infection control, Light-curing unit, Sleeves, Wrapping.

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Introduction

Dental light-curing units (LCUs) have become essential equipment in dentistry, especially with the use of composites and adhesives. Light-curing units are exposed to the intraoral environment during use in a clinical setting; hence, infection control has to be maintained between uses. Instruments that could contact oral tissues (without penetration) are classified as semicritical and will be needing sterilization or disinfection.[1] If a semicritical item is heat-sensitive, it should be processed with high-level disinfection.[1] Light-curing units are classified as semicritical instruments,[1,2] as they are used intraorally but do not penetrate into deeper structures. High-level disinfectants, if not sterilization, should be employed to control cross infection.[2] Some models of LCUs have removable light-guiding tips that can be sterilized and reused or even disposable tips. Nevertheless, physical barriers should be used to reduce, if not prevent, contamination of parts of the LCUs, especially the light-guiding tip that is most often placed into the oral cavity. A few authors have conducted studies on the effect of infection control barrier on LCUs and their power output and concluded that most of the infection control barrier methods do not produce clinically significant reduction.[3–10] Some authors studied effect of infection control barrier on LCUs and the hardness of the cured composites and concluded that most of the infection control barrier methods do not produce clinically significant reduction;[3,5,6,8] the light output intensity will directly affect cure of the composite. A few authors explored cling films as a form of infection control barrier.[3–7,10,11] With the considerations of the research involving efficacy of a cling film as an infection-control barrier and microbial contamination,[11,12] as well as two-layer infection control barrier,[13] our study will explore the effect on light output and clinical efficacy of the cling film and compare with sleeves.

[1]Department of Paediatric Dentistry, Faculty of Dentistry, MAHSA University, Selangor, Malaysia

[2]Department of Dental Radiology, International Medical University, Kuala Lumpur, Malaysia

[3]Department of Public Health Dentistry, YMT Dental College and Hospital, Mumbai, Maharashtra, India

[4–6]Department of Oral Health, MAHSA University, Selangor, Malaysia

Corresponding Author: Swarna Y Math, Department of Dental Radiology, International Medical University, Kuala Lumpur, Malaysia, Phone: +60 183279785, e-mail: SwarnaYerebairapura@imu.edu.my

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Aim

To compare and assess the level of infection control provided by a cling film against a sleeve and their impact on the light intensity level of dental light-emitting diode (LED) LCUs.

Objectives

- Compare the level of infection control provided by a cling film and a sleeve on dental LED LCUs.
- Assess the effect of a sleeve and a cling film on the light output intensity of dental LED LCUs.

Hypothesis

The barriers in the form of cling films and sleeves help to prevent cross contamination and at the same time reduce the light output intensity of the LED LCUs.

Materials and Methods

Materials and Equipment

Assessment of Light Output Intensity

- Light-emitting diode light-curing units with fixed light-guiding tips
- Radiometer
- Sterile surgical gloves (Mexpo International Inc., Blossom®)
- Oxobiodegradable pen-type curing light sleeves (Premium Plus International Ltd)
- Domestic food grade cling film (C. I. Kasei Co., Ltd)
- Disinfecting wipes (Beviston, BevistoCryl Wipes)

Assessment of Infection Control

- Light-emitting diode light-curing units with fixed light-guiding tips of same model types
- Sterile latex surgical gloves (Mexpo International Inc., Blossom®)
- Latex examination gloves
- Face masks
- Biodegradable pen-type curing light sleeves (Premium Plus International Ltd)
- Cling film (C. I. Kasei Co., Ltd)
- Disinfecting wipes (Beviston, BevistoCryl Wipes)
- Autoclaved cotton swabs
- Peptone water (ISOLab Sdn. Bhd.)
- Columbia agar with 5% sheep blood (ISOLab Sdn. Bhd.)
- Glass rod
- Pipette
- Test tubes
- Test tube racks
- Bunsen burner
- Class II biological safety cabinet
- Incubator.

Methods

We conducted the procedures in the year 5 clinics of Faculty of Dentistry and Microbiology Lab of Faculty of Biomedical Sciences in MAHSA University, Bandar Saujana Putra campus.

Assessment of Light Output Intensity

We checked LED LCUs and their light-guiding tips for damage, and then selected 10 units in good condition. We first used the 10 selected LCUs as group I "without barrier," then applied a sleeve on each light-guiding tip as group II "with sleeve," and finally removed the sleeves and applied two layers of cling film as group III "with cling film" (Fig. 1).

We checked the radiometer for error and calibrated it accordingly. The selected LCUs were left to charge for an hour. We set each LCU to maximum output and recorded their output intensity using the radiometer; we then replaced them back to their respective charging bases. Each team member did the same procedures after a delay of 10 minutes to allow the LCUs to charge; the data obtained were tabulated, and the average of readings of each sample was calculated.

Fig. 1: Cling film applied properly onto the light-guiding tip of a LCU without creases and air bubble entrapment

Assessment of Infection Control

We assigned each member as operator, sampler, timer, and patient. We chose five similar models of LED LCUs, checked their light-guiding tips for damage, and kept them inside the running biological safety cabinet. The sampler randomly chose a LCU and wiped its light-guiding tip along its length using a disinfecting wipe. The LCU was left to dry in the biological safety cabinet for 5 minutes.

For assessment of infection control, we collected 10 samples for group I "positive control" and group II "negative control" each and 35 samples for group III "sleeve" and group IV "cling film" each.

For positive control samples, we obtained, cultured, and assessed the sample as per above, after disinfecting the light-guiding tip but without placing a barrier and simulating intraoral use.

For negative control samples, we obtained, cultured, and assessed the sample as per above, after disinfecting the light-guiding tip and simulating intraoral use without use of a barrier.

For determination of achievement of proper disinfection in the methodology, we conducted the procedures for the positive control sample after a certain number of test samples.

For analysis, we assessed the area of surface coverage by the colonies via photographs of the inoculated surfaces, and then we tabulated the data obtained.

The sampler, who was wearing the sterile surgical gloves, applied a randomly chosen barrier onto the light-guiding tip inside the biological safety cabinet. The operator, who was wearing examination gloves, then took the LCU from its charging base and introduced it into the patient's oral cavity, with the tip targeted at tooth 37 (lower left second molar). The operator gently pushed the light-guiding tip against the patient's left buccal mucosa to simulate intraoral use without rubber dam and maintained in position for 40 seconds. The operator then removed the LCU from the patient's mouth and returned it to the charging base in the biological safety cabinet. The operator carefully removed the barrier from the LCU, and the barrier is disposed into the clinical waste bin. The sampler immediately swabbed the sample upon opening of the barrier; the sample was obtained from the first 3 cm of the left and right (buccal and lingual/palatal intraorally) sides of the light-guiding tip, using an autoclaved cotton swab that was dipped into peptone water. The sampler then transferred the swab into a test tube containing 1 mL of peptone water and stirred gently for 30 seconds. The sampler then sealed the test tube opening with a cling film, and then the

operator transferred the test tube from the biological safety cabinet to the incubator. The test tube was placed on a test tube rack in the incubator and left inside at 37°C for 5 minutes. The sampler disinfected the LCU using the disinfecting wipes and left the LCU to dry in the biological safety cabinet for 5 minutes. The operator then moved the test tube from the incubator to the biological safety cabinet, and then the sampler unsealed it and poured the liquid onto an agar plate for inoculation. The liquid was swished around the surface of the agar and then gently stirred using a sterile glass rod. The sampler closed the agar plate and then the operator placed it into the incubator. We incubated the samples for 48 hours at 37°C and then placed them sequentially in the biological safety cabinet for photographing of the inoculated surface (Fig. 2). We disposed samples after completion of the research into the clinical waste bin.

Data Analysis

The data obtained were compiled in a Microsoft Office 2010 Excel Sheet and subjected to statistical analysis using Statistical Package for Social Sciences (SPSS ver. 21.0, IBM). Since the data of microbial counts were coded in an increasing grade, they are considered as ordinal for analysis. In addition, the data on intensity were skewed and did not follow a normal curve; hence, nonparametric tests were used for comparisons. Intergroup comparison of microbial counts was done using the Kruskal–Wallis ANOVA followed by pairwise comparisons using the Mann–Whitney *U* test. In addition, frequencies of various grades of microbial counts between the groups were calculated using the Chi-square test. Intergroup comparison of light intensity was done using the Kruskal–Wallis ANOVA followed by pairwise comparisons using the Mann–Whitney *U* test. For all the statistical tests, $p < 0.05$ was considered to be statistically significant, keeping α error at 5% and β error at 20%, thus giving a power to the study as 80%.

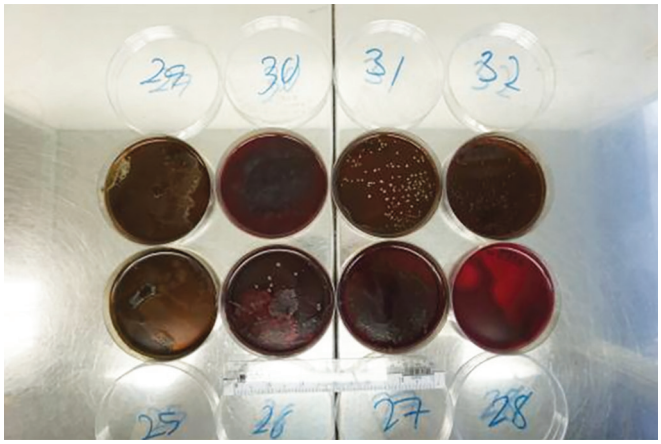

Fig. 2: A series of samples, after completing their post-48 hours photography procedure

Results

Assessment of Light Output Intensity

A total of 120 samples were obtained; the distribution of samples is listed in Table 1.

Table 2 shows that there is an average of 6.724 and 7.320% reduction of light output intensity, respectively, for groups II "with sleeve" and III "with cling film" compared to group I "without barrier."

Table 1 shows there is a statistically nonsignificant difference ($p > 0.05$) between light intensities of all groups.

Table 3 shows there is a statistically nonsignificant difference ($p > 0.05$) between all group pairs. Therefore, we find that there is no significant difference in light output intensity even with application of a barrier and no significant difference between either barrier choices.

Assessment of Infection Control

We analyzed the photos and assigned a grade to the samples as per the rubric in Table 4. A total of 90 samples were obtained. The distribution of samples is listed in Figure 3.

We found statistically highly significant difference ($p < 0.01$) in Figure 3 of frequency distribution of various grades of microbial counts between the groups. All of the group II "negative control" samples were of grade III and IV, which are 50% and above coverage of the inoculated surface. In contrast, all of the samples with barriers in groups III and IV, and as well as the group I "positive control," are of low area coverage, mostly in grade I.

Table 1: Intergroup comparison of light output intensity using the ANOVA test

Group	*Samples*	*Mean*	*Standard deviation*	*Standard error*	*χ^2 value*	*p value of KW ANOVA*
I	40	875.00	191.485	30.277	3.949	0.139
II	40	818.75	189.360	29.941		
III	40	813.75	192.066	30.368		

Table 2: Data collected for light output intensity

	I (without barrier)	*II (with sleeve)*	*III (with cling film)*	*Light output reduction of II*	*Light output reduction of III*
Mean	875	818.75	813.75	6.724%	7.320%

Table 3: Pairwise comparison between groups for light output intensity using the Mann–Whitney *U* test

Group	*versus group*	*Mann–Whitney U*	*Z*	*p value*
II	III	794	−0.058	0.954
	I	624	−1.703	0.088
III	I	621	−1.732	0.083

Table 4: Rubric for inoculated surface samples

Criteria	*Grade assigned*
None	0
Colonies covering 1–25% area	I
Colonies covering 25–50% area	II
Colonies covering 50–75% area	III
Colonies covering >75% area	IV

We found statistically highly significant difference ($p < 0.01$) (Table 5) of intergroup comparison of microbial counts. The highest mean was found in group II "negative control," followed by groups III "sleeve" and IV "cling film" having equal means, and the least for the group I "positive control."

Table 6 shows statistically highly significant difference ($p < 0.01$) for all groups compared to group II "negative control." However, there is a statistically nonsignificant difference ($p > 0.05$) for comparisons between groups I "positive control," III, and IV. Hence, we found that both sleeve and cling film are equally efficacious as a cross-contamination barrier choice.

Discussion

Instruments and equipment in a dental setting can be of reusable or disposable types. As resin restorations are becoming more popular, usage of dental LCU is a mainstay. The LCU has to be used between multiple patients, and it is a fomite of cross infection. A pilot study has found significant contamination of the LCU,[12] and hence, it is of utmost importance to maintain proper disinfection protocols in between patients.

The cross-infection control protocol recommended by CDC for semicritical instruments[1] is of autoclave protocol or use of high-level disinfectant. Surface disinfectants can degrade the LCU parts, and henceforth care needs to be taken to use the appropriate disinfectant as recommended by the manufacturer.[15]

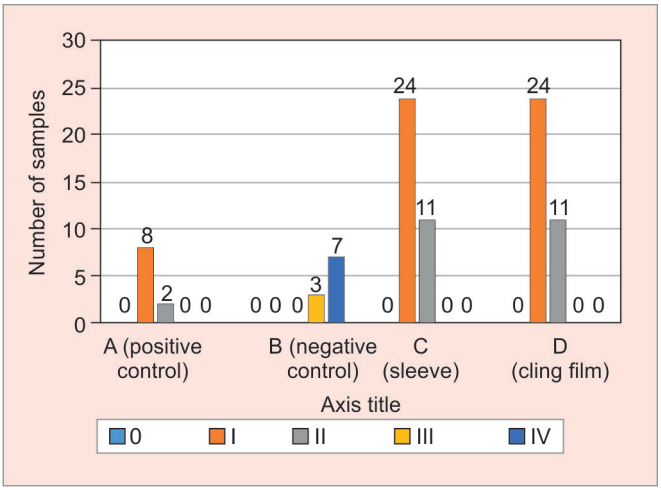

Fig. 3: Data collected for microbial culture

We found that many of the LCUs in our university have fixed nonautoclavable light-guiding tips. Hence, to reduce contamination of the surface of the LCUs, it is recommended to apply a barrier.

Applying a transparent barrier can effectively prevent cross infection by LCUs and may simultaneously cause reduction of the light output intensity from the LCU.[15]

Our aim was to ensure that the LCU used for the patient helps to reduce contamination as practically achievable and yet not compromising on the light intensity produced. The choice of barriers for LCUs has been researched by other authors with regards to light output intensity,[3–10] and some authors have concluded it will directly affect the hardness of the cured composites.[3,5,6,8] Considering the possibility of a cling film as an infection-control barrier from prior studies,[11,12] as well as a two-layer infection control barrier,[13] our study explored its effects on light output and clinical efficacy of a cling film and compared it against sleeves.

From our data, there was no significant reduction of intensity for both cling film and sleeves vs the output without application of a barrier. Similar studies have found that the reduction does not significantly affect the curing of the composite and its final hardness.[3,8,10,13] Our data obtained were from objective observation of an analog radiometer, which could be subject to operator errors and interoperator differences. There are digital radiometers in the market that can provide readings that are more accurate; nevertheless, it is advisable to ensure the light output is above the threshold for the curing of the composites as per manufacturer's instructions.

Hwang et al. studied the effect of a multilayer infection control barrier on the microhardness of a composite resin, using hardness of the cured composite resin as an indicator of the effective light intensity of LCU after coverage with one, two, four, and eight layers of a disposable wrap barrier. Our research were of two groups, the first having two layers of cling wrap and the latter having one layer of sleeve, which is in line with their results that up to two layers do not produce significant cured resin hardness reduction.[13]

Hodsan et al. reported significant reduction in the mean power density readings with the use of disposable barriers (greater

Table 5: Intergroup comparison of microbial culture using the ANOVA test

Groups	*Samples*	*Mean*	*Standard deviation*	*Standard error*	*χ^2 value*	*p value of KW ANOVA*
I	10	1.20	0.422	0.133	36.016	0.000
II	10	3.70	0.483	0.153		
III	35	1.31	0.471	0.080		
IV	35	1.31	0.471	0.080		

Table 6: Pairwise comparison between groups for microbial culture using the Mann–Whitney *U* test

Group	*versus group*	*Mann–Whitney U*	*Z*	*p value*
III	IV	612.500	0.00	1.000
	I	155.00	−0.695	0.600
	II	0.00	−5.244	0.000
IV	I	155.00	−0.695	0.600
	II	0.00	−5.244	0.000
I	II	0.00	−4.004	0.000

Fig. 4: Sleeve does not fit easily into this shape of a LCU

Fig. 5: Presence of a seam of sleeve on the tip of a LCU

reduction with sleeves than cling wrap) compared to the no-barrier control, the results of which are contradictory to our results.[6]

AlShaafi found that the use of a disinfectant and a barrier on the LCU tips resulted in reduction of power output by 12.4% after 25 infection control cycles. Although the decrease in the light output intensity was minimal, the tips were swabbed with a disinfectant between cycles/patients, which resulted in greater reduction of the power output.[16] The reduction after the first cycle was 6.6%, which is in line with our results. There was a marked percentage of reduction between the first and fifth cycles, from 6.6 to 12.4%.[16]

The sleeve tested was designed for a certain design of light-guiding tip but did not fit all the various designs of LCUs (Fig. 4) available in our university clinic; hence, ease of use may be reduced in certain cases.[9,10] The cling film was also occasionally fraught with air bubble entrapment or seam (Fig. 5) but to a lesser degree than sleeve. These air bubbles entrapped will reduce light output, hence should be avoided by careful application of the barriers.[4,8,9] Nevertheless, there were rare tearings of the cling film due to overstretching. These factors should be taken in consideration for choice of a barrier. Additionally, consideration should be given to the appearance of the barrier to the client of a clinic.[9]

On the efficacy of the two types of barriers in reducing contamination of the light-guiding tip of LCUs, the data found significant reduction in the area of the inoculated surface covered by bacterial colonies and therefore is correlated to the reduction of contamination of the light-guiding tips. Cling wrap has been studied as a contamination barrier, and also in use of LCUs, in so far to be compared with sleeves and other barriers for its effect in light output intensity and composite curing.[4–7,9–11,13]

None of the group had zero colonies, not even the group I "positive control," which did not have barrier applied nor intraoral placement; this could be due to contaminants from handling, exposure to air, or procedural errors.[9,11] The procedural errors may be compounded by use of glass rods that have been sterilized by heat between samples multiples times or contamination of the sterile gloves of the sampler. Practically, these barriers may not be sterile during use, perhaps so even before they have been opened.[11] Nevertheless, practical use of these barriers in a clinical setting will most likely to have contamination through handling and exposure to air but will not hamper their efficacy as cross-contamination barriers.[11] Other authors have suggested using a heavy-duty cling film instead of a domestic cling film, as the thicker laminate found in the former reduces risk of possible microscopic holes.[11,14]

Our research did not pursue into identifying and classifying the cultured bacteria, hence we are unable to deduce the origin of the cultured bacteria. Furthermore, the protocol of incubation does not support anaerobes or nonbacterial organisms, hence it may not fully elucidate the absence or presence of other microorganisms. Additionally, our microbial cultures were limited to surface coverage analysis, which is subjective; further research can be conducted using objective and quantitative analysis of bacterial count through multiple dilutions and cultures. Furthermore, research can be done into the inoculated colonies to identify their type and perhaps origin, be it intraoral commensal and pathogen or environmental contaminant.

Conclusion

Within the limitations of our study, we found that both sleeve and cling film are suitable choices of cross-contamination barriers. The choice between these two lies with the operator, considering their cost, ease of use, and potential application beyond LCUs. However, the light cure LCU should be maintained in good condition and producing sufficient light output intensity. Furthermore, the barriers should be kept in an area not exposed openly to the clinical environment and not be contaminated unnecessarily during handling prior to their use. Not only that, barriers are not replacement to standard disinfection and sterilization protocols. Further research with clinical trials, larger sample sizes, and advanced techniques and tests should be investigated to ascertain the feasibility of these barriers in a clinical setting and also their risk as fomites if misused.

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