

# Effect of Disposable Infection Control Barriers on Light Output from Dental Curing Lights

(Effet des barrières jetables de prévention de l'infection sur le flux lumineux des lampes à polymériser)

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## S o m m a i r e

**Objet :** Afin de prévenir la contamination du guide de lumière d'une lampe à polymériser, des barrières comme des enveloppes ou des revêtements plastiques jetables peuvent être utilisées. Dans cette étude, on a comparé l'effet de 3 barrières jetables sur le spectre d'émission et la densité de puissance d'une lampe à polymériser. L'hypothèse était qu'aucune des barrières n'aurait d'effet clinique significatif sur le spectre d'émission ni sur la densité de puissance de la lampe à polymériser.

**Méthodologie :** Trois barrières jetables ont été testées par rapport à un témoin (aucune barrière). Le spectre d'émission et la densité de puissance de la lampe à polymériser ont été mesurés avec un spectromètre fixé à une sphère d'intégration. Les mesures ont été répétées à 10 occasions distinctes en séquence aléatoire pour chaque barrière.

**Résultats :** L'analyse de variance (ANOVA) suivie par un test de la plus petite différence significative protégée de Fisher a montré que la densité de puissance était significativement moins élevée que pour le témoin (de 2,4 % à 6,1 %) lorsque 2 barrières jetables offertes dans le commerce étaient utilisées ( $p < 0,05$ ). Il n'y avait pas de différence significative au chapitre de la densité de puissance lorsqu'on utilisait une enveloppe en plastique tout usage ( $p > 0,05$ ). L'effet de chacune des barrières sur la puissance de sortie était faible et probablement sans signification clinique. Les comparaisons ANOVA de la valeur de la longueur d'onde moyenne de pointe ont indiqué qu'aucune des barrières n'a produit de changement significatif du spectre d'émission par rapport au témoin ( $p > 0,05$ ).

**Conclusions :** Deux des 3 barrières jetables ont produit une réduction significative de la densité de puissance de la lampe à polymériser. Ce déclin de puissance était faible et n'aurait probablement aucun effet préjudiciable sur la polymérisation de la résine composite. Aucune des barrières n'a agi comme filtre de lumière.

**Mots clés MeSH :** comparative study; composite resins/chemistry; dental equipment; light

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Cet article a été révisé par des pairs.

The development of resins has been rapid since the introduction of light-cured composites in the 1970s, and their use has become more widespread.<sup>1,2</sup> Initially, light-cured resins were used only where esthetics demanded a tooth-coloured restoration. More recently, resins have been used for posterior restorations, as luting agents and for provisional restorations.<sup>3</sup> A survey published in 1998 showed that 27% of dentists used posterior resin composites almost exclusively for posterior restorations.<sup>1</sup>

Light-cured resins contain photo-initiators, which are activated by blue light to begin the polymerization process.<sup>4</sup> The

light must have sufficient intensity and must be of the correct wavelength to activate the photo-initiator.<sup>5</sup> The rapid development of light-curing units (LCUs) has paralleled that of resins. Current models deliver greater light intensities and offer faster curing times than older models. The light intensity delivered by an LCU is influenced by many factors, such as fluctuations in the line voltage, the condition of the bulb and filters, deposition of resin at the curing tip, breakdown of electrical components and fracture of the fibre optic bundles within the unit.<sup>6,7</sup> Both the physical and the biological properties of the resin are affected by the degree of polymerization.<sup>8</sup> The minimum light

intensity required to adequately cure 1.5 to 2 mm of composite resin is reportedly between 280 and 300 mW/cm<sup>2</sup>.<sup>8,9</sup> Inadequate curing of the composite may cause problems such as premature breakdown at the margins and staining of the restoration,<sup>10</sup> dimensional instability, decreased biocompatibility of the resin<sup>8,11</sup> and increased cytotoxicity.<sup>12,13</sup>

Dental offices must maintain a high level of infection control to protect both patients and personnel, yet the LCU light guides used when curing resins are often in direct contact with oral tissues. In 1989 Caughman and others<sup>14</sup> reported that contamination of light guides and LCU handles was common after clinical use. Currently, the 4 most common methods of maintaining sterility of the light guide are wiping the guide with a disinfectant, such as glutaraldehyde, after each patient use; using autoclavable guides;<sup>15</sup> using presterilized, single-use plastic guides;<sup>16</sup> and using translucent disposable barriers to cover the guide.<sup>17</sup> Each of these methods is discussed briefly here.

Various disinfectant solutions may be used to clean light guides. Caughman and others<sup>14</sup> found that 2% glutaraldehyde in a substituted phenolic solution eliminated all viable bacteria when the guide was wiped or kept wrapped for 10 minutes in a cloth saturated with the solution. However, a wipe soaked in 70% ethanol did not remove all viable bacteria.<sup>14</sup> Wiping with a disinfectant solution is quick and convenient, but longer than 10 minutes of contact with the disinfectant is recommended to ensure virucidal and sporicidal action. Some studies have shown that glutaraldehyde-based solutions may reduce light transmission through a light guide or damage the fibres in the light guide.<sup>18–20</sup> Nelson and others<sup>20</sup> found that immersion of light guides in Cidex 7 (Johnson & Johnson Medical, New Brunswick, NJ), an alkaline 3.4% glutaraldehyde-based solution, for 1,000 hours resulted in a 49% decrease in light intensity, which could not be totally reversed by polishing the end of the light guides. Dugan and Hartleb<sup>18</sup> reported that immersing light guides in Cidex 7 for 4 days caused irreversible structural breakdown in the glass fibres in the light guide. This breakdown of the glass fibres might cause the light to scatter, which may result in a decrease in light output.

LCU light guides can be autoclaved to ensure sterility, but autoclaving may reduce the ability of the guide to transmit light from the LCU to the tooth. The light intensity at the tip of the guide may be decreased to 50% of its original value after the guide has been autoclaved 3 times in non-deionized water.<sup>15</sup> However, when distilled water was used in the autoclave, the light intensity decreased by only 6.25% after 30 cycles in the autoclave.<sup>21</sup> If the tips of the guides were polished after autoclaving, the light intensity returned to its original value.<sup>15,21</sup> Although polishing may restore light transmission, it is time consuming to autoclave and polish the tips. Also, repeated autoclaving and polishing may permanently damage the guide and result in additional costs for the clinician and patient.

Single-use plastic light guides eliminate the time and expense of sterilization and light guide maintenance.<sup>16</sup> Depending on the LCU and the type of plastic guide used,

there may be an increase (up to 14%) or a decrease (up to 8%) in light output from the LCU.<sup>16</sup> Also, light intensity may be significantly reduced (by 23%) if the sides of the clear plastic light guide come into contact with the oral tissues.<sup>16</sup>

Use of disposable translucent barriers such as plastic wrap, light tip sleeves and finger cots may be a cost-effective alternative to avoid contamination of the light guide. Such barriers provide a convenient, noninvasive method of preventing contact between the oral tissues and the guide. They also eliminate the risk of damaging the guide during autoclaving or chemical disinfection.<sup>17</sup> However, previous studies have reported that the light intensity may fall by up to 35% when some barriers are used. Warren and others<sup>22</sup> found that 4 different types of barrier used on each of 4 different light guides all reduced light output. One barrier reduced the power density from the curing light by up to 110 mW/cm<sup>2</sup>. Cellophane wrapped around the light guide has been reported to cause the least reduction in power density from the curing light.<sup>17</sup> Although these studies were useful, they may have produced misleading results because a dental radiometer was used to measure light intensity. Many dental radiometers do not provide consistent measurements, they do not report wavelength, and they may not accurately measure light intensity.<sup>3,5</sup> Leonard and others<sup>3</sup> found that the accuracy of dental radiometers varied by as much as 80% and was dependent on the diameter of the light guide. Unlike a dental radiometer, a laboratory-grade spectrometer connected to an integrating sphere can capture and measure all light output from an LCU and provides a visual display of the spectral output. For these reasons, a laboratory-grade spectrometer should be used to measure power output from dental curing lights as well as to record their spectral outputs.

The purpose of this study was to compare the effect of 3 barriers on the spectral output and power density from a dental curing light. The null hypothesis was that for clinical purposes none of the barriers would significantly affect either the spectral output or the power density from the dental curing light.

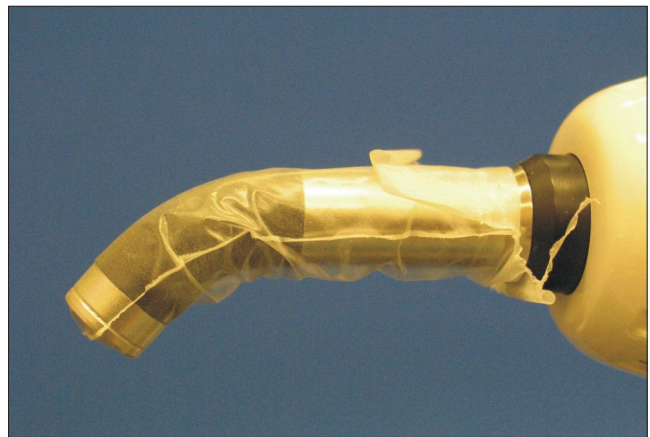
## Methods and Materials

Three disposable barriers were tested: 2 commercially available barriers (Cure Sleeve, Arcona-Henry Schein Inc., Melville, NY, and Cure Elastic Steri-shield, Santa Barbara, Calif.), and general-purpose plastic wrap (Saran Cling Plus, S.C. Johnson & Son Inc., Brantford, Ont.). **Figures 1a, 1b, and 1c** show the light guide covered with each of the 3 barriers.

The same Optilux 501 LCU (Kerr USA, Orange, Calif.) with an 11-mm standard light guide was used throughout the study. An Ocean Optics model USB 2000 spectrometer (Ocean Optics, Dunedin, Fla.) was used, along with Ocean Optics OOIrrad software (version 2.05.00 PR7), to record the data. The spectrometer was calibrated according to a National Institute of Standards and Technology (Gaithersburg, Md.) light source. The tip of the light guide was placed over the aperture of an integrating sphere, which captured all light from the guide. The following 3 measurements were recorded:



**Figure 1a:** Optilux 501 light guide with Saran plastic wrap over the guide.



**Figure 1b:** Optilux 501 light guide with Cure Sleeve over the guide.



**Figure 1c:** Optilux 501 light guide with Cure Elastic over the guide.

total power (mW), peak wavelength (nm) and irradiance at the peak value (mW/nm).

The light output was measured on 10 separate occasions for each barrier and with no barrier (control). New barriers were placed on the light guide for each recording, and the tip of the guide was wiped clean after each session with a Kimwipe EX-L tissue (Kimberly-Clark Corp., Roswell, Ga.). A random number table was used to assign the order in which data for the barriers and control were recorded ( $n = 40$ ). The LCU was warmed up by running for two 40-second curing cycles before the light output was measured. To reduce initial variation in light output from the LCU, data were recorded 10 seconds into the curing cycle.

The power recordings obtained from the spectrometer were converted into power density values (mW/cm<sup>2</sup>) by dividing the total power by the area of the tip of the light guide, since this is the unit in which values are commonly reported when LCUs are assessed. Analysis of variance (ANOVA) and Fisher's protected least significant difference (PLSD) test for multiple comparisons were used to determine if there were significant differences in total power delivered between the control and the 3 disposable barriers. The data were evaluated at the 95%

confidence level. The mean power density for each of the barriers was also compared with the control to determine the percentage reduction in power density.

## Results

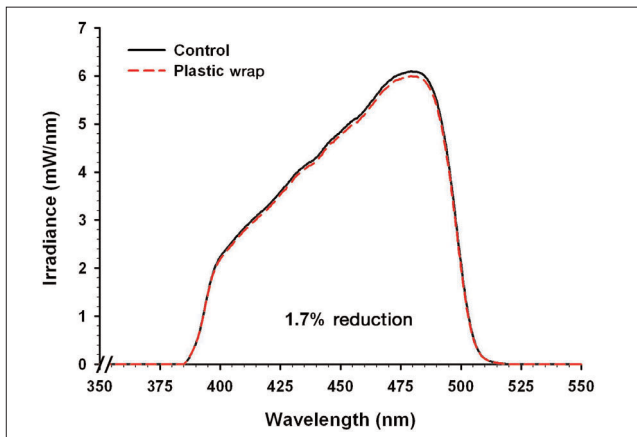
Figures 2, 3 and 4 show the effects on spectral output and power output (the area under the spectral curve) of placing a barrier over the end of the light guide compared to the power output recorded with no barrier over the light guide (control). Table 1 shows the mean power density, the percent reduction in power density, and the mean peak wavelength for each of the 3 barriers and the control. The light guide that was not covered by a barrier delivered the highest power densities, and the Cure Elastic barrier produced the lowest. The mean peak wavelength measurements were very similar for the control and all 3 barriers, ranging from 478.8 to 479.6 nm.

ANOVA followed by Fisher's PLSD test for multiple comparisons (Table 2) showed that there was a significant difference in power density between the control (no barrier) and the Cure Sleeve and Cure Elastic barriers ( $p < 0.05$ ). However, there was no significant difference in power density between the control and the Saran plastic wrap ( $p > 0.05$ ). Figure 5 shows the effect of each of the barriers on mean power density. The effect of the Cure Elastic and Cure Sleeve barriers, although statistically significant, was small and not likely to be clinically significant. Figure 6 shows the effect of each of the barriers on mean peak wavelength. ANOVA for mean wavelength peak values indicated that none of the barriers produced a significant shift in the peak spectral output relative to the control ( $p > 0.05$ ).

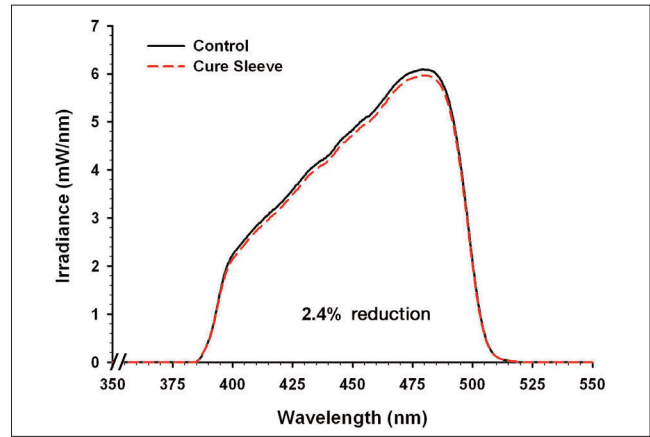
The hypothesis that none of the barriers would affect the spectral output from the LCU was accepted. The hypothesis that none of the barriers would affect the power density from the LCU was rejected for the Cure Sleeve and the Cure Elastic, but was accepted for the plastic wrap.

## Discussion

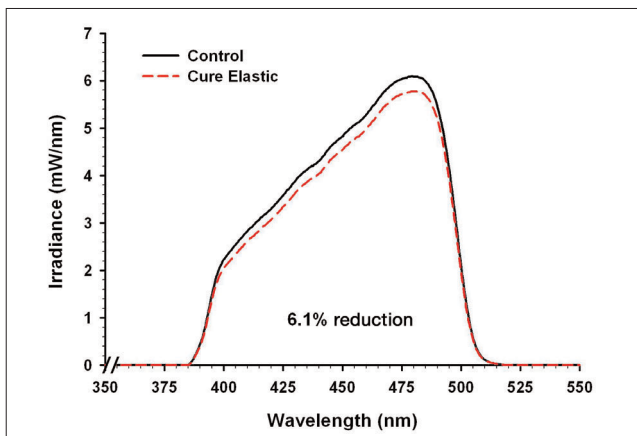
It is important that light guides used for curing resin composites in the mouth be sterile. At the same time, it is



**Figure 2:** Effect on light output when plastic wrap was placed over the light guide.



**Figure 3:** Effect on light output when Cure Sleeve was placed over the light guide.



**Figure 4:** Effect on light output when Cure Elastic was placed over the light guide.

important to ensure that the resin receives sufficient power density and appropriate spectral output for adequate curing. This study showed that 2 of the infection-control barriers tested (Cure Sleeve and Cure Elastic) significantly reduced the power density from the LCU, but Saran plastic wrap had no significant effect on power density (Fig. 5).

The distance from the tip of the light guide to the resin has a much greater effect on power density than these disposable barriers. It has been reported that a 1-mm space between the light guide and the resin may cause a reduction in power density of between 8% and 16%.<sup>23</sup> The effect of the Cure Sleeve and the Cure Elastic on power density, although statistically significant, was smaller (2.4% and 6.1% respectively) than the reduction that would occur with a 1-mm space. This reduction in power was not considered large enough to warrant further tests on the effects of these barriers on resin polymerization. None of the barriers caused the control power density (573 mW/cm<sup>2</sup>) to drop below the recommended 280–300 mW/cm<sup>2</sup>.<sup>8,9</sup> Therefore, if the LCU is working properly, it will still deliver adequate power density when using any of the barriers tested in this study. Chong and others<sup>17</sup> also found that none of the barriers they tested reduced the power

density below 300 mW/cm<sup>2</sup>, and they reported that Cellophane wrap had the least effect. However, a 1999 report<sup>24</sup> indicated that the power output from 55% of curing lights in dental offices was below 300 mW/cm<sup>2</sup>. Therefore, using disposable barriers on these lights might have a deleterious clinical effect on resin polymerization.

If the wavelengths of light from the LCU are significantly affected when a disposable barrier is used, the resin might not be completely cured. However, the peak wavelength of light transmitted through each of the 3 barriers was not significantly different from the peak wavelength emitted from the control. Figures 2, 3 and 4 also show that, apart from the power reduction, the spectrum from the light guides covered by the barriers was very similar to the control spectrum. Therefore, all of the barriers were translucent, and none acted as a filter between the LCU and the tooth.

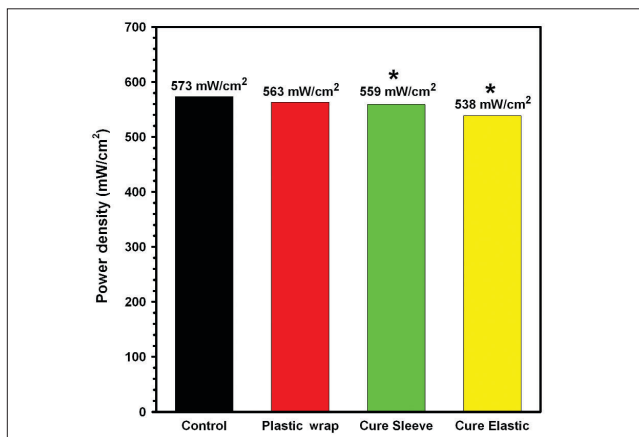
When choosing a procedure to disinfect light guides, clinicians should consider several aspects, including cost. If the light guides are to be autoclaved between patients, then it will be necessary to purchase additional guides, each costing \$200 to \$325, depending on the size and model. Disposable Cure Sleeve barriers cost \$63 for a box of 400 (\$0.16 per patient), Cure Elastic barriers cost \$35 for a box of 500 (\$0.07 per patient) and Saran plastic wrap is the most cost effective at about \$2.90 for 60 m. Approximately 10 cm of plastic wrap is sufficient to cover a light guide; 60 m of plastic wrap would be sufficient to cover 500 light guides.

Ease of use is also important, especially in a busy practice. Although Saran plastic wrap had the least effect on light output, plastic wrapped around the light guide did not have a professional appearance (Fig. 1a). The Cure Sleeve was relatively easy to place and covered the entire light guide, but it was more expensive and some practice was needed to position the sleeve properly. Also, an air pouch often formed at the end of the tip. This could cause problems because the clinician might not be able to bring the tip of the light guide against the surface of the tooth. The Cure Elastic barriers were easiest to place over the guide because they slid on quickly and stretched tight over the end. However, they did not cover the entire light

**Table 1** Mean power density, percent reduction in power density and mean peak wavelength for control (no barrier) and 3 barriers, as measured by an integrating sphere

Barrier	Mean power density $\pm$ SD (mW/cm <sup>2</sup> )	% reduction in power density (relative to control)	Mean peak wavelength $\pm$ SD (nm)
Control (no barrier)	573 $\pm$ 6	NA	479.1 $\pm$ 0.5
Saran plastic wrap	563 $\pm$ 20	1.7	478.8 $\pm$ 0.3
Cure Sleeve	559 $\pm$ 11	2.4	479.5 $\pm$ 0.8
Cure Elastic	538 $\pm$ 13	6.1	479.6 $\pm$ 0.7

SD = standard deviation, NA = not applicable



**Figure 5:** Effect of each barrier on mean power density from the light guide. Asterisk indicates a significant difference from the control, which had no barrier ( $p < 0.05$ ).

guide, which would mean that part of the light guide would still have to be wiped down between patients (Fig. 1c).

Clinicians should also consider the sterility of the barriers. None of the barriers used in this study is marketed as a sterile covering. Only Cure Sleeves come in a prepackaged, single-use bag, which protects the disposable barrier from contacting its surroundings until the bag is opened. Cure Elastic barriers are packed in bulk and could easily become contaminated in the box. They are exposed to the surrounding environment each time the box is opened, when they could become contaminated by airborne organisms or by a contaminated foreign body.

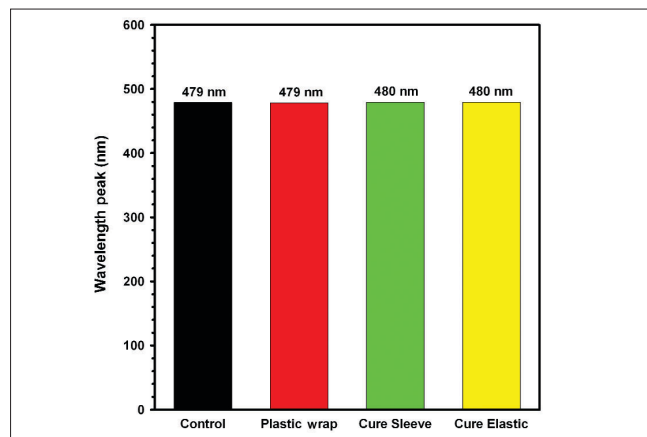
Further studies are required to investigate if these barriers have an effect on light dispersion. Although this study showed that they had little effect on the total power output from an LCU, they may cause the light to scatter from the end of the light guide. This may adversely affect the amount of light energy received at the bottom of a deep preparation.

## Conclusions

Two of the 3 disposable barriers tested produced a statistically significant reduction in power density ( $p < 0.05$ ), but the

**Table 2** Mean difference in power density for the 3 barriers, relative to control (analysis of variance and Fisher's protected least significant difference test)

Comparison	Mean difference in power density (mW/cm <sup>2</sup> )	$p$ value
Control v. Saran plastic wrap	10	0.09
Control v. Cure Sleeve	14	0.020
Control v. Cure Elastic	35	$< 0.001$



**Figure 6:** Effect of each barrier on mean peak wavelength emitted from the curing light. There were no significant differences from the control (no barrier) ( $p > 0.05$  for all comparisons).

reduction was small (2.4% to 6.1%) and would probably not have an adverse clinical effect on the curing of composite resin. None of the translucent barriers affected the spectrum of light emitted from the LCU ( $p > 0.05$ ). ♦

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