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

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Abstract

Purpose: *To prevent contamination of the light guide on a dental curing light, barriers such as disposable plastic wrap or covers may be used. This study compared the effect of 3 disposable barriers on the spectral output and power density from a curing light. The hypothesis was that none of the barriers would have a significant clinical effect on the spectral output or the power density from the curing light.*

Methods: *Three disposable barriers were tested against a control (no barrier). The spectra and power from the curing light were measured with a spectrometer attached to an integrating sphere. The measurements were repeated on 10 separate occasions in a random sequence for each barrier.*

Results: *Analysis of variance (ANOVA) followed by Fisher's protected least significant difference test showed that the power density was significantly less than control (by 2.4% to 6.1%) when 2 commercially available disposable barriers were used ($p < 0.05$). There was no significant difference in the power density when general-purpose plastic wrap was used ($p > 0.05$). The effect of each of the barriers on the power output was small and probably clinically insignificant. ANOVA comparisons of mean peak wavelength values indicated that none of the barriers produced a significant shift in the spectral output relative to the control ($p > 0.05$).*

Conclusions: *Two of the 3 disposable barriers produced a significant reduction in power density from the curing light. This drop in power was small and would probably not adversely affect the curing of composite resin. None of the barriers acted as light filters.*

MeSH Key Words: *comparative study; composite resins/chemistry; dental equipment; light*

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The development of resins has been rapid since the introduction of light-cured composites in the 1970s, and their use has become more widespread.[1,2] 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.[3] A survey published in 1998 showed that 27% of dentists used posterior resin composites almost exclusively for posterior restorations.[1]

Light-cured resins contain photo-initiators, which are activated by blue light to begin the polymerization process.[4] The light must have sufficient intensity and must be of the correct wavelength to activate the photo-initiator.[5] 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.[6,7] Both the physical and the biological properties of the resin are affected by the degree of polymerization.[8] The minimum light intensity required to adequately cure 1.5 to 2 mm of composite resin is reportedly between 280 and 300 mW/cm^2.[8,9] Inadequate curing of the composite may cause problems such as premature breakdown at the margins and staining of the restoration,[10] dimensional instability, decreased biocompatibility of the resin[8,11] and increased cytotoxicity.[12,13]

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[14] 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;[15] using presterilized, single-use plastic guides;[16] and using translucent disposable barriers to cover the guide.[17] Each of these methods is discussed briefly here.

Various disinfectant solutions may be used to clean light guides. Caughman and others[14] 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.[14] 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.[18–20] Nelson and others[20] 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[18] 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.[15] However, when distilled water was used in the autoclave, the light intensity decreased by only 6.25% after 30 cycles in the autoclave.[21] If the tips of the guides were polished after autoclaving, the light intensity returned to its original value.[15,21] 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.[16] 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.[16] 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.[16]

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.[17] However, previous studies have reported that the light intensity may fall by up to 35% when some barriers are used. Warren and others[22] 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^2. Cellophane wrapped around the light guide has been reported to cause the least reduction in power density from the curing light.[17] 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.[3,5] Leonard and others[3] 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.

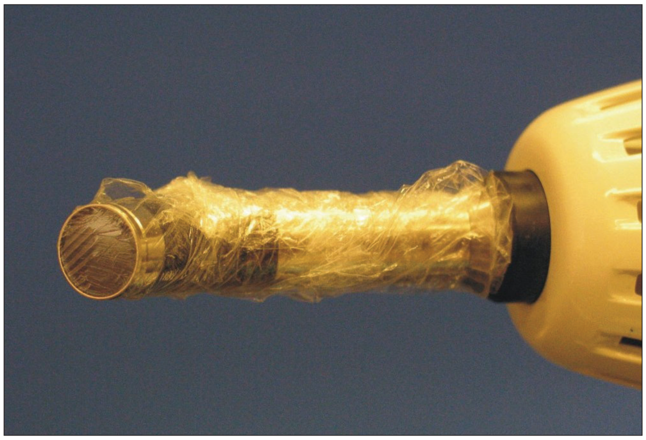

Figure 1a: *Optilux 501 light guide with Saran plastic wrap over the guide.*

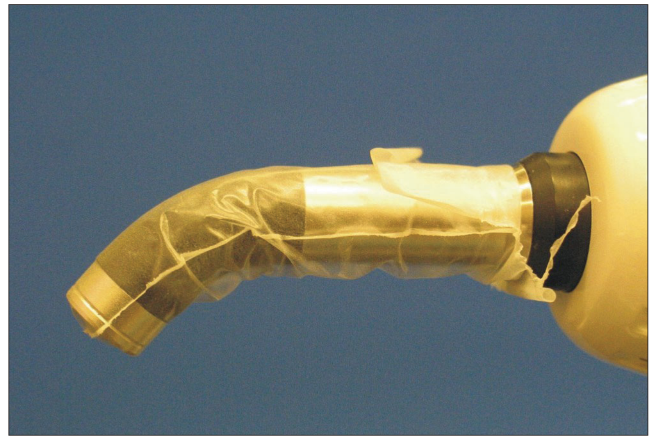

Figure 1b: *Optilux 501 light guide with Cure Sleeve over the guide.*

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

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 OOIIrrad 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: 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^2) 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

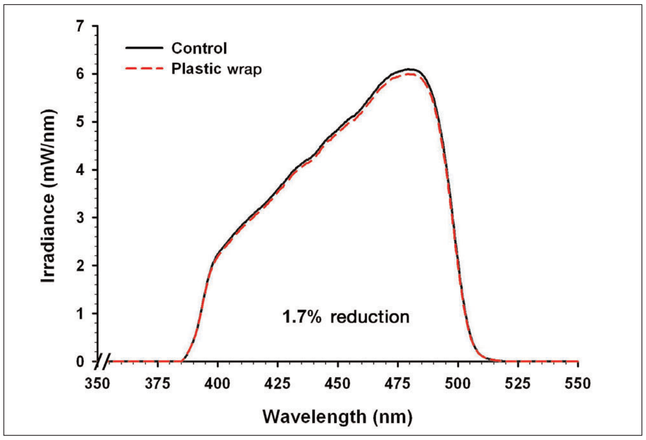

***Figure 2:** Effect on light output when plastic wrap was placed over the light guide.*

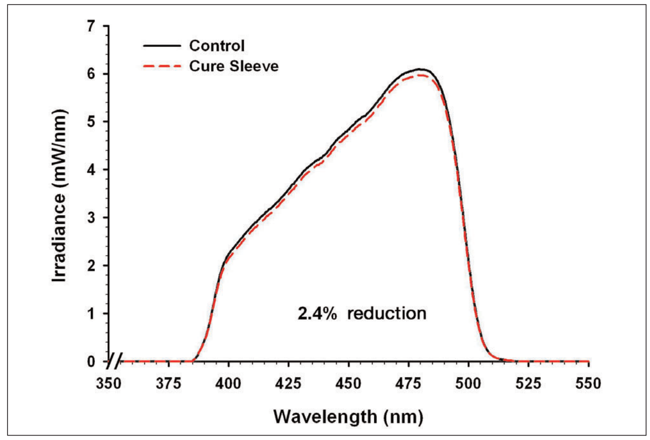

***Figure 3:** Effect on light output when Cure Sleeve was placed over the light guide.*

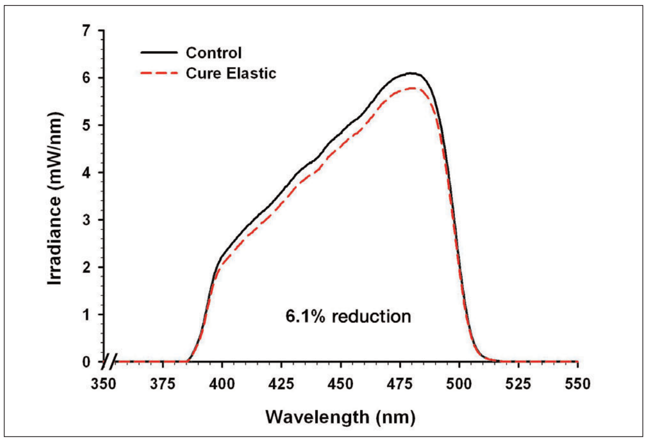

***Figure 4:** Effect on light output when Cure Elastic was placed over the light guide.*

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 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%.[23] 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^2) to drop below the recommended 280–300 mW/cm^2.[8,9] 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[17] also found that none of the barriers they tested reduced the power density below 300 mW/cm^2, and they reported that Cellophane wrap had the least effect. However, a 1999 report[24] indicated that the power output from 55% of curing lights in dental offices was below 300 mW/cm^2. 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.

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 ± SD (mW/cm²)	% reduction in power density (relative to control)	Mean peak wavelength ± SD (nm)
Control (no barrier)	573 ± 6	NA	479.1 ± 0.5
Saran plastic wrap	563 ± 20	1.7	478.8 ± 0.3
Cure Sleeve	559 ± 11	2.4	479.5 ± 0.8
Cure Elastic	538 ± 13	6.1	479.6 ± 0.7

SD = standard deviation, NA = not applicable

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/cm²)	*p* value
Control v. Saran plastic wrap	10	0.09
Control v. Cure Sleeve	14	0.020
Control v. Cure Elastic	35	< 0.001

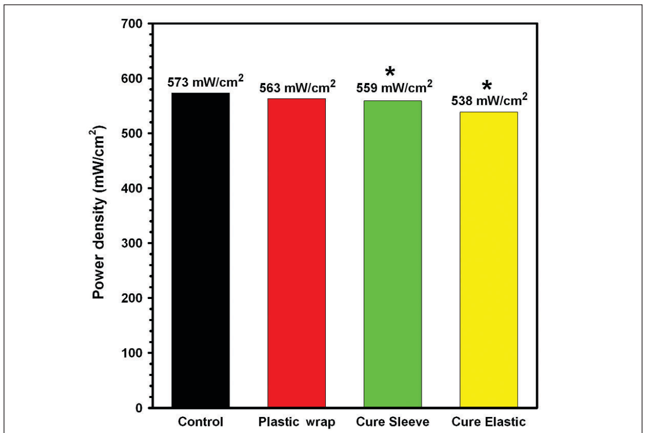

Figure 5: *Effect of each barrier on mean power density from the light guide. Asterisk indicates a significant difference from the control, which had no barrier (p < 0.05).*

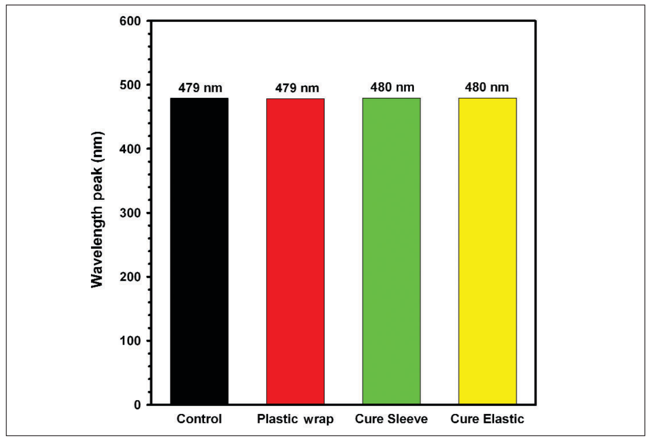

Figure 6: *Effect of each barrier on mean peak wavelength emitted from the curing light. There were no significant differences from the control (no barrier) (p > 0.05 for all comparisons).*

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 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 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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References

1. Christensen GJ. Current use of tooth-colored inlays, onlays, and direct-placement resins. *J Esthet Dent* 1998; 10(6):290–5.

2. Forss H, Widstrom E. From amalgam to composite: selection of restorative materials and restoration longevity in Finland. *Acta Odontol Scand* 2001; 59(2):57–62.

3. Leonard DL, Charlton DG, Hilton TJ. Effect of curing-tip diameter on the accuracy of dental radiometers. *Oper Dent* 1999; 24(1):31–7.

4. Anusavice KJ. Phillips' science of dental materials. 11th ed. St. Louis: Elsevier Science; 2003. p. 411.

5. Rueggeberg FA. Precision of hand-held dental radiometers. *Quintessence Int* 1993; 24(6):391–6.

6. Shortall AC, Harrington E, Wilson HJ. Light curing unit effectiveness assessed by dental radiometers. *J Dent* 1995; 23(4):227–32.

7. Sakaguchi RL, Douglas WH, Peters MC. Curing light performance and polymerization of composite restorative materials. *J Dent* 1992; 20(3):183–8.

8. Caughman WF, Rueggeberg FA, Curtis JW Jr. Clinical guidelines for photocuring restorative resins. *J Am Dent Assoc* 1995; 126(9):1280–2, 1284, 1286.

9. Fan PL, Schumacher RM, Azzolin K, Geary R, Eichmiller FC. Curing-light intensity and depth of cure of resin-based composites tested according to international standards. *J Am Dent Assoc* 2002; 133(4):429–34.

10. 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(1):57–61.

11. Ferracane JL. Correlation between hardness and degree of conversion during the setting reaction of unfilled dental restorative resins. *Dent Mater* 1985; 1(1):11–4.

12. Chen RS, Liuiw CC, Tseng WY, Hong CY, Hsieh CC, Jeng JH. The effect of curing light intensity on the cytotoxicity of a dentin-bonding agent. *Oper Dent* 2001; 26(5):505–10.

13. Caughman WF, Caughman GB, Shiflett RA, Rueggeberg F, Schuster GS. Correlation of cytotoxicity, filler loading and curing time of dental composites. *Biomaterials* 1991; 12(8):737–40.

14. Caughman GB, Caughman WF, Napier N, Schuster GS. Disinfection of visible-light-curing devices. *Oper Dent* 1989; 14(1):2–7.

15. Rueggeberg FA, Caughman WF, Comer RW. The effect of autoclaving on energy transmission through light-curing tips. *J Am Dent Assoc* 1996; 127(8):1183–7.

16. Rueggeberg FA, Caughman WF. Factors affecting light transmission of single-use, plastic light-curing tips. *Oper Dent* 1998; 23(4):179–84.

17. Chong SL, Lam YK, Lee FK, Ramalingam L, Yeo AC, Lim CC. Effect of various infection-control methods for light-cure units on the cure of composite resins. *Oper Dent* 1998; 23(3):150–4.

18. Dugan WT, Hartleb JH. Influence of a glutaraldehyde disinfecting solution on curing light effectiveness. *Gen Dent* 1989; 37(1):40–3.

19. Nelson SK, Ruggeberg FA, Heuer GA, Ergle JV. Effect of glutaraldehyde-based cold sterilization solutions on light transmission of single-use, plastic light-curing tips. *Gen Dent* 1999; 47(2):195–9.

20. Nelson SK, Caughman WF, Rueggeberg FA, Lockwood PE. Effect of glutaraldehyde cold sterilants on light transmission of curing tips. *Quintessence Int* 1997; 28(11):725–30.

21. Kofford KR, Wakefield CW, Nunn ME. The effect of autoclaving and polishing techniques on energy transmission of light-curing tips. *Quintessence Int* 1998; 29(8):491–6.

22. Warren DP, Rice HC, Powers JM. Intensity of curing lights affected by barriers. *J Dent Hyg* 2000; 74(1):20–3.

23. Price RB, Dérand T, Sedarous M, Andreou P, Loney RW. Effect of distance on the power density from two light guides. *J Esthet Dent* 2000; 12(6):320–7.

24. Pilo R, Oelgiesser D, Cardash HS. A survey of output intensity and potential for depth of cure among light-curing units in clinical use. *J Dent* 1999; 27(3):235–41.