The effect of disposable infection control barriers and physical damage on the power output of light curing units and light curing tips

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IN BRIEF

- Shows that cross infection control barriers can indirectly affect the cure of light-activated resin composite.
- Demonstrates that food wrap material is just as effective a barrier as some commercial products.
- Highlights that the effects of physical damage along with those of cross infection control measures should be considered clinically important.

RESEARCH

This study investigated the effects that disposable infection control barriers and physical damage through use had on the power output from dental light curing units (LCUs) and light curing tips (LCTs). Five disposable infection control barriers were tested on a number of LCUs and LCTs. Testing involved the repeated measurement of power output of LCUs and LCTs on a radiometer. Two of the barriers tested caused statistically significant reductions in the mean light output intensity when compared to the no barrier control groups. One barrier type reduced the power output by 30 to 40%. It was also noted that physical damage to the LCTs affected power output by between 20 and 30%, which was then further reduced by the disposable barrier. This study showed that three of the five disposable infection control barriers had little effect on the overall efficiency of the power output of the LCUs. It also showed that physical damage to LCUs and LCTs can affect power output significantly. Infection control measures should be carefully considered before use to avoid undue effects on power output delivered from the LCUs/LCTs to ensure that the degree of polymerisation within the resin-based composite and curing efficiency are not affected unduly.

INTRODUCTION

Over the past decade, the use of resin-based composite restorative material has increased dramatically in popularity in general dental practice. Light-activated resin-based composites are particularly popular as they offer a high degree of polymerisation, are 'command-set' and reduce clinical time expended in their placement. Again, over the past decade, the mode of delivery of activating light has undergone refinement with the introduction of quartz-tungsten halogen (QTH) and light-emitting diode (LED) light curing units of increasing sophistication and efficiency. Studies indicate that LED LCUs have become increasingly popular in recent years with laboratory experiments confirming that LED LCUs are as efficient as QTH LCUs when polymerising resin-based composite materials.[1–3]

The optimal polymerisation of resin-based composite increases its physical properties and the eventual performance of the restoration with the degree of polymerisation depending on a number of factors, including:

- Light intensity and exposure time
- Temperature of the material
- The distance and angle between light and resin-based composite material
- The angle and path of the light and heat generated by the LCU
- The shade of the resin-based composite material
- The type of filler and amount of photo-initiator in the material
- The thickness of the resin-based composite material
- Air inhibition and effects due to ambient temperature or the operatory light used in the surgery.

LCUs are prone to material and bacterial contamination after use[4] and a variety of measures can be employed to reduce and prevent this. One of the most acceptable measures used to prevent cross or material contamination of the LCU tip infection is through the use of transparent disposable barriers that cover the light curing tip[5–7] and is an alternative to the use of disinfectants or autoclaving and polishing techniques.[8,9] Disposable barriers are marketed as a cost-effective way of avoiding contamination of the light tip and prevent damage to the light guide caused by other means such as autoclaving, disinfection or polishing procedures. The long term adherence of composite resin or bonding agent to the light tip, which has been shown to affect between 35% to 68% of light cure units, reduces the efficiency of the LCU.[10,11] It has been reported that some disposable barriers can affect light intensity with a potential decrease of up to 35% and reduce output to below the optimal level of 300 mW/cm² (Fan *et al.*, 2002).[5,11] Physical damage to rigid light curing guides and tips occurs through use and it is not unreasonable to believe that such physical damage affects performance of the associated LCU.

The aims of this study were to test and compare the effect that commercially available infection control barriers had on the light output of LCUs and degree of

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Online article number E12
Refereed Paper – Accepted 9 December 2010
DOI: 10.1038/sj.bdj.2011.312

polymerisation from selected light-curing units, compare the results of alternative disposable barriers and determine the effect that physical damage had on the power output of light sources. The null hypothesis stated that neither the barriers nor physical damage would have a significant effect on the power output from the selected LCUs.

MATERIALS AND METHODS

Initially, the power output of the four LCUs (Table 1) was measured ten times with a radiometer, following the manufacturer's instructions. Each LCU had a new unused curing tip and these measurements established the control values for the study. Following this, the measurement process was repeated for the light sources with each of the five disposable barriers (Table 2) which have been suggested as having potential with respect to infection control in the dental surgery. A new barrier was used on each occasion and measurements were recorded ten times for each barrier and tip used. The measurement process was then repeated in the same way on a number of used LCU tips (six in total, two for the Demetron light source and four for the Coltolux 75 light source) to assess the effect that physical damage (Fig. 1) sustained through clinical use and sterilisation procedures had on power output. As above, the measurements on each of the LCTs were measured with and without the disposable barriers. All data was entered into an Excel datasheet before importing into an SPSS datasheet for statistical analysis.

Table 1 Light curing units used in the study

Light curing unit	Manufacturers' details
Coltolux 75	Coltene-Whaledent Ltd, West Sussex, UK
Coltolux LED	Coltene-Whaledent Ltd, West Sussex, UK
Demetron	Demetron, Kerr, UK
Smartlite PS	Dentsply Limited, Addlestone, UK

Table 2 Disposable barriers used in the study

Disposable barrier	Manufacturers' details
'Cling film' disposable food barrier	Spar (UK)
'Cling film' disposable food barrier	Tesco (UK)
Barrier sleeve	Coltene-Whaledent Ltd, West Sussex, UK
Finger cots	JP Safe Limited, Kowloon, Hong Kong
Dental plastic gloves	Bennett Safetywear Ltd, Liverpool, UK

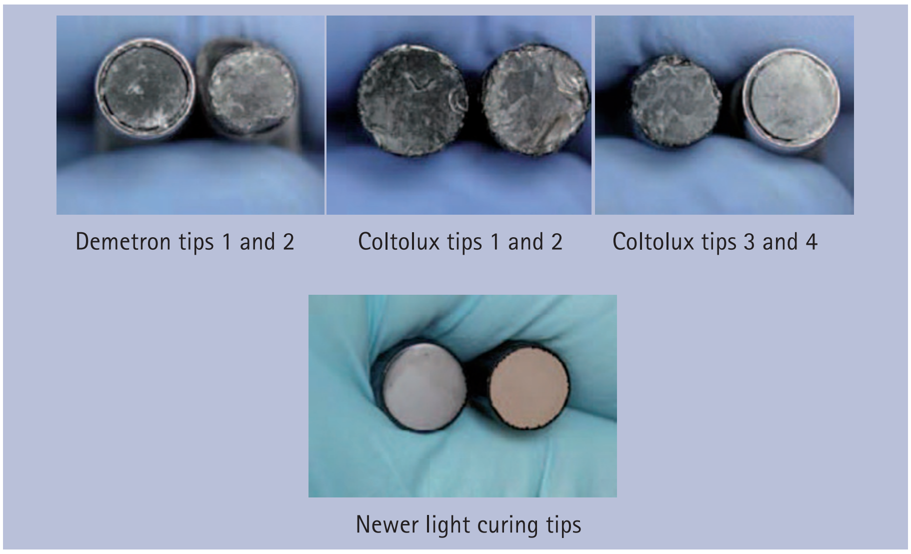
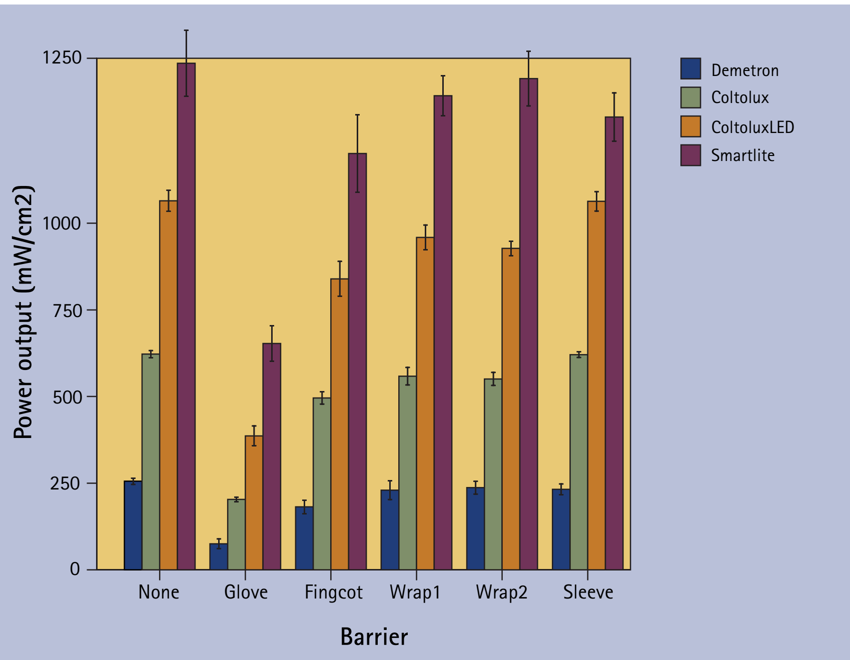


Fig. 1 Examples of the light curing tips tested and an indication of the physical damage they had sustained consequent to repeated clinical use, autoclaving and disinfection; for comparison two newer less damaged tips are also shown

RESULTS

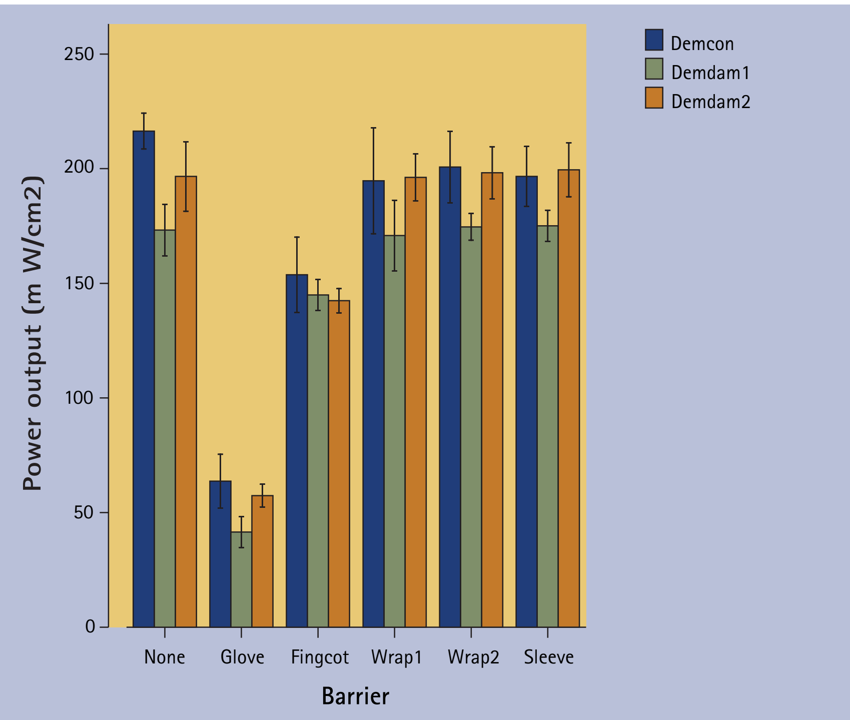
The mean power outputs for each of the undamaged (control) LCUs and the effects that the disposable barriers had on power output are detailed in Figure 2. An unpaired t-test was used to analyse where statistically significant differences between the mean power outputs (compared to the no barrier control data and analysed through an independent t-test) occurred; significant differences are indicated on the chart. It was noted that the mean reduction in power output for the gloved test reduced power output by 55-87% (dependent on light source), which was much greater than the finger cot test group (18-30%), the food wrap barriers (7-13%) and the polythene sleeve (1-11%). Although not shown in this paper, the standard deviations calculated from the results showed that the LCUs performed relatively consistently during testing and no significant differences in the power output of each light source were noted. This finding was also affirmed through the analysis of box and whisker plots, which highlighted no outliers to the means in the analysis of the data by specific group barrier.

The results of power output of light curing tips that had undergone some damage and the effects of the disposable barriers are detailed in Figures 3 and 4. Statistically significant differences (calculated by t-tests) in power output following physical damage when compared to the no-barrier control were shown as were significant reductions in power output when the effect of the infection control barrier was also taken into consideration. It was noted that for the Demetron light source damage to the LCTs caused a reduction in power output by 10-20% without including the effects of the barriers (Fig. 3). When the barriers were included, power output was further reduced with the dental glove barrier having most significant reduction in power output (Fig. 3). For the Coltolux 75 light source (Fig. 4), physical damage also



	None	Glove	Finger cot	Wrap 1	Wrap 2	Sleeve
Demetron	216.4	63.70	153.7	194.7	200.7	17.33
Coltolux 75	527.1	172	420	473	466.4	525.8
Coltolux LED	901.8	337.3	711.1	812.4	785.4	900.5
Smartlite	1237.7	553	1017.3	1158.4	1200.4	196.6

Fig. 2 Mean power output (mW/cm²) of the light curing used and the effect that using the barriers had on power output; significant differences between the control and the barriers are shown above the bars. The error bars represent the 95% confidence interval



	None	Glove	Finger cot	Wrap 1	Wrap 2	Sleeve
Dem (control)	216.4	63.70	153.7	194.7	200.7	196.6
Dem (dam1)	173.2	41.5	157	170.8	174.6	174.8
Dem (dam2)	196.6	57.4	143.5	196.2	198.2	199.5

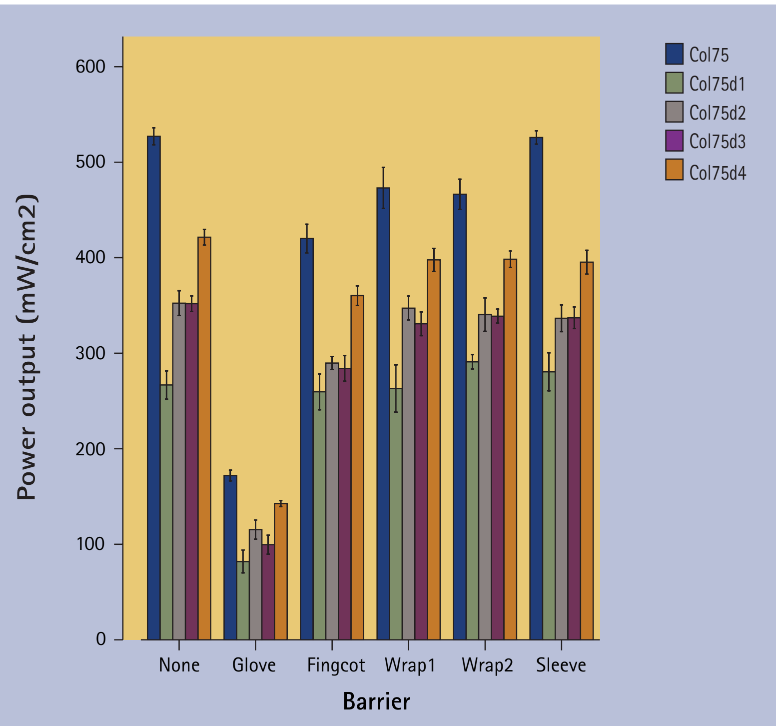
Fig. 3 Mean power output (mW/cm²) of the 'damaged' Demetron light curing tips and the effect of damage; significant differences between the undamaged light (control) and the damaged tips are shown above the bars. The error bars represent the 95% confidence interval

reduced power output and this ranged from 20 to 50% and was dependent on the amount of damage sustained by the LCTs. Power output was further reduced by the use of a disposable infection control barrier (Fig. 4).

DISCUSSION

Inadequately polymerised resin-based composite restorations lead to marginal breakdown and reductions in the mechanical properties of composite such as decreased strength, increased wear, increased water sorption and reduced colour stability. Additionally, incompletely polymerised restorations can cause pulpal irritation, decrease restoration longevity and increased incidence of recurrent caries. The effectiveness of curing of light-activated dental materials depends on LCUs emitting light of sufficient intensity and of the correct wavelength. There are numerous factors that can affect the efficiency of light curing units that include the age of the curing light, the condition of the bulb and filter, the contamination of the light guide and autoclave-induced damage to the fibre-optic bundle.[12,13]

The results of this study suggest that disposable infection control barriers can have a significant reduction on power output of LCUs and LCTs. However, this is dependent on the LCU, disposable barrier and physical damage to the tip. It was shown that with some LCUs and LCTs these factors were able to reduce power output below the recommended threshold as sufficient for optimal curing of resin-composite (300 mW/cm², Fan *et al.* 2002). This was particularly noticeable for the dental glove and finger cot groups tested. Studies have shown that a value of light output below 200 mW/cm² is a cause for concern.[14] In this study, both the dental glove and finger cot groups when tested resulted in power outputs on some occasions below this level, particular concern being shown with the dental glove as an infection control barrier as it reduced output by up to 71% and decreased curing power to 63.7 mW/cm². While these measurements are based on a 20-second curing time, it is of concern that such power output values measured may have a significant bearing on the effective cure of any light activated dental material; clearly such effects need close and careful



	None	Glove	Finger cot	Wrap 1	Wrap 2	Sleeve
Col 75	527.1	172.0	420.0	473.0	466.4	525.8
Col 75 dam1	266.7	82.0	259.6	263.1	291.0	280.5
Col 75 dam2	352.4	115.3	289.7	347.2	340.4	336.6
Col 75 dam3	351.9	99.6	284.1	330.8	338.8	337.1
Col 75 dam4	420.4	142.7	284.1	397.7	398.4	395.3

Fig. 4 Mean power output (mW/cm²) of the 'damaged' Coltolux 75 light curing tips and the effect of damage; significant differences between the undamaged light (control) and the damaged tips are shown above the bars. The error bars represent the 95% confidence interval

investigation. It was noted that all barriers when used with the Demetron light source reduced the output and brought it near to the cause for concern value of 200 mW/cm². The only other instance for concern was noted in the Coltolux 75 LCU measurements when the dental glove was used as a barrier, with a power output of 172 mW/cm² being recorded.

When the effect of physical damage through use was evaluated on the Demetron tips it was noted that physical damage had a significant and deleterious effect on power output, which was further affected by the infection control barriers. The dental glove had the worst effect, although with both damaged Demetron light tips the 200 mW/cm² output value was breached on all occasions. These deleterious effects were again pronounced in the Coltolux 75 group when dental gloves were used. It was also noted that the finger cot group also had an observable reduction on power output with all 4 tested LCTs having a power output measured below 300 mW/cm².

It is evident from this research that LCTs' being subjected to physical damage through use reduces power output, which can then be further reduced by covering with a disposable infection control barrier. The newer LED light sources, which cannot undertake the rigours of autoclaving/sterilisation procedures as tips can, are less likely to be subject to such physical damage. However, the clinician does have to practise some suitable methods of infection control and it would appear that commercially available barriers and cling-film type disposable food wraps provide that function without seriously affecting power output. It should be noted that it is recommended that LCUs and LCTs be regularly maintained and that power output to be checked on a regular basis to ensure efficient curing.

It is noticeable that, as well as providing suitable cross infection controls, disposable barriers also prevent the light tip being coated in resin adhesives and also provide a degree of protection against physical damage. The practice of covering a light tip with a barrier fabricated from a dental glove cannot be advocated on the strength of this research.

CONCLUSION

Commercially available light curing sleeves or commonly available cling film used as appropriate infection control barriers do not significantly reduce power output. The use of gloves or other opaque barriers causes a significant reduction in the power output from LCUs, compromising effective polymerisation. Damage to light curing tips also reduces power output of LCUs to ineffective levels.

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